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SPEED OF SUBURBANIZATION: ROXY INDEX ANALYSIS FOR INTRA-METROPOLITAN SPATIAL REDISTRIBUTION OF POPULATION IN JAPAN

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CONTENTS

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1. INTRODUCTION

One indicator for measuring the speed of spatial concentration or deconcentration of population in a system of metropolitan areas, is the ROXY index. This index is defined as follows for the period between year t and year t+1[1];

$$\left(\frac{\text{weighted average growth ratio}}{\text{simple average growth ratio}} - 1.0\right) \times 10{,}000$$

where weighted average growth ratio:

$$\sum_{i=1}^{n} X_{i,t+1} / \sum_{i=1}^{n} X_{i,t}$$

simple average growth ratio:

$$\sum_{i=1}^{n} (X_{i,t+1} / X_{i,t}) \times \frac{1}{n}$$

$X_{i,t}$: population level of metropolitan area i in year t

n : number of metropolitan areas.

Note that the weighting factor for the above ROXY index is the population level of each metropolitan area in year t.

In Japan, there are eighty-six metropolitan areas called Functional Urban Cores (FUCs)[2] which are the Japanese version of Standard Metropolitan Statistical Areas (SMSAs)[3]. The recent ROXY index study[4] shows that, in the urban system composed of those eighty-six FUCs, the population was continuously concentrating to larger FUCs[5] during the 1960-80 period, but that the speed of concentration constantly decelerated over time. The study also shows that the urban system which is composed of the thirty largest FUCs experienced population concentration before 1970 with its speed decelerating. For a while around 1970, population growth became roughly balanced, among different population-size groups of thirty FUCs, and the population deconcentration started after 1970 with its speed accelerating over time[6].

The aforementioned results imply that the disurbanization stage[7] which is conceived in the "spatial cycle hypothesis" would come into the Japanese urban system of eighty-six FUCs, in a foreseeable future[8]. This implication would arouse our research interests in examining the recent suburbanization patterns of the three largest metropolitan areas in Japan to obtain a better insight into (i) the relationships between the spatial cycle stages of the Japanese urban system and those of the three largest metropolitan areas, (ii) the differences in spatial cycle stages among the three largest metropolitan areas, and (iii) the differences in spatial cycle stages among several regions, each of which are along separate railway lines that extend radially from the central business district (CBD) of the central city of the three largest individual metropolitan areas. Such research interests have actually driven the author to study the patterns of intra-metropolitan spatial redistribution process of population for Tokyo, Osaka and Nagoya FUCs by means of the analytical method of ROXY index. The results of the study are shown in the present paper.

2. SPEED OF SUBURBANIZATION

In our study, we use the ROXY index, whose weighting factor is the distance to the CBD of the central city for a metropolitan area from each of the subareas of that metropolitan area. Mathematically, the ROXY index of this kind is formulated as;

$$\left(\frac{\text{weighted average growth ratio}}{\text{simple average growth ratio}} - 1.0\right) \times 10{,}000$$

$$= \left(\frac{\sum_{i=1}^{n} d_i r_i^{t,t+1}}{\sum_{i=1}^{n} d_i} \times \frac{n}{\sum_{i=1}^{n} r_i^{t,t+1}} - 1.0 \right) \times 10^4$$

$$= \frac{n \sum_{i=1}^{n} d_i r_i^{t,t+1} - \sum_{i=1}^{n} d_i \times \sum_{i=1}^{n} r_i^{t,t+1}}{\sum_{i=1}^{n} d_i \times \sum_{i=1}^{n} r_i^{t,t+1}} \times 10^4$$

where d_i : distance from subarea i to CBD,

$r_i^{t,t+1}$: population growth ratio of subarea i for the period between year t and year t+1, growth ratio being defined as the population level in year t+1 divided by the population level in year t,

n : number of subareas.

For this ROXY index[9], Table 1 shows the relationships between (i) the value of ROXY index, (ii) the intra-metropolitan spatial redistribution pattern of population shares, (iii) the direction of changes in the value of ROXY index, and (iv) the changes in the speed of centralization or suburbanization of population. The spatial cycle concept[10] which underlies the contents of this table is diagrammatically expressed in Figure 1.

(a) Wave Diagram

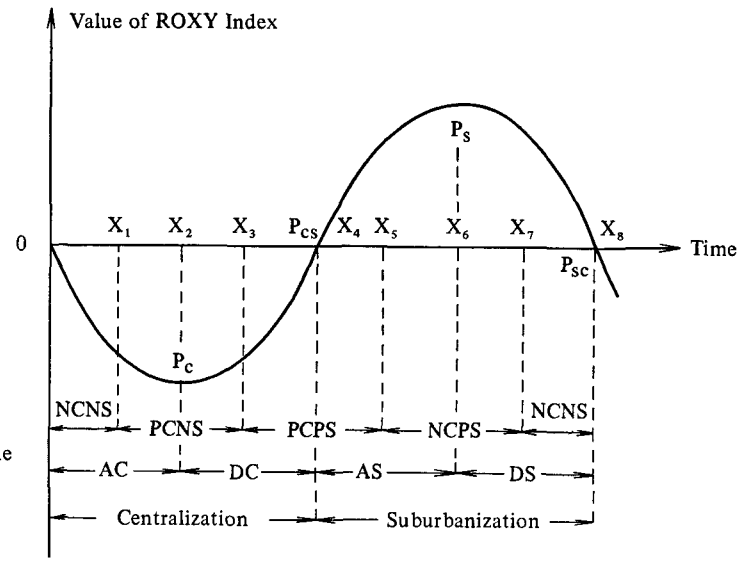
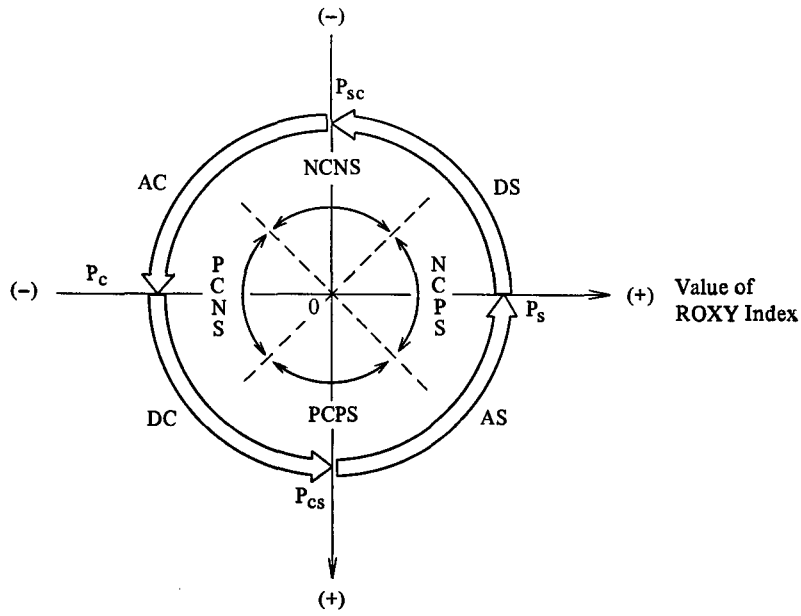


Fig. 1 ROXY Index and Life Cycle of a Metropolitan Area (Spatial Cycle Scheme in terms of ROXY Index)

(b) Circle Diagram



(Note)

1. AC: Accelerating Centralization
2. DC: Decelerating Centralization
3. AS: Accelerating Suburbanization
4. DS: Decelerating Suburbanization
5. P_C: Zenith Point of Centralization
6. P_{CS}: Turning Point from Centralization Stage to Suburbanization Stage
7. P_S: Zenith Point of SuburbanizationsSpeed
8. P_{SC}: Turning Point from Suburbanization Stage to Centralization Stage
9. PCNS: Possible Positive Growth in Central Area (Inner-ring Area) and Negative Growth in Suburban Area (Outer-ring Area)
10. PCPS: Possible Positive Growth in both Central and Suburban Areas
11. NCPS: Possible Negative Growth in Central Area and Positive Growth in Suburban Area
12. NCNS: Possible Negative Growth in both Central and Suburban Areas
13. It should be noted that the lower portion of the vertical axis in the "Circle Diagram" presents positive values and that its upper portion presents negative values.

Fig. 1 (Continued)

Table 1 Implications of ROXY Index for Intra-metropolitan Spatial Redistribution Processes of Population (Weighting Factor: Distance to CBD)

(i) Value of ROXY Index	(ii) Intra-metropolitan Spatial Redistribution Pattern of Population Shares	(iii) Direction of Changes in Value of ROXY Index	(iv) Speed of Spatial Redistribution of Population
ROXY > 0	Suburbanization of Population (Dispersion of Population)	→ (1) → (2) → (3)	(1) Accelerating (2) Stabilizing (3) Decelerating
ROXY = 0	Symmetric Growth or Decline of Population (viz. BGD, BSGD or CSGD of Population)	0.0 → 0.0	Can not be specified
ROXY < 0	Centralization of Population (Agglomeration of Population)	→ (1) → (2) → (3)	(1) Decelerating (2) Stabilizing (3) Accelerating

(Note)

1. BGD: Balanced Growth or Decline (Namely, the growth rate curve is nearly flat, reflecting the constant share of population over different distance-zone groups of localities.)
2. BSGD: Bell-shaped Growth or Decline (Namely, the growth rate curve is bell-shaped, reflecting the "medianization" of population over distance-zone groups. This "medianization" means increase in population share by middle distance-zone groups of localities and, at the same time, decrease in population share by near and far distance-zone groups of localities.)
3. CSGD: Cup-shaped Growth or Decline (Namely, the growth rate curve is cup-shaped, reflecting the "bipolarization" of population over distance-zone groups. This "bipolarization" means increase in population share by near and far distance-zone groups of localities and, at the same time, decrease in population share by middle distance-zone groups of localities.)
4. In this table, special attention should be paid to the fact that, for the intra-metropolitan spatial redistribution processes of population, *negative* values of ROXY index would imply agglomeration phenomenon. In constrast with this, for the inter-metropolitan spatial redistribution processes of population as shown in Table N-1, *positive* values of ROXY index would imply agglomeration phenomenon. One of the possible means to make positive values of ROXY index to imply agglomeration phenomenon for the intra-metropolitan spatial redistribution processes of population, would be to employ d^{-i} as a weighting factor; where d indicates the distance from each locality to the CBD of the central city of the metropolitan area to which that locality belongs and i indicates any positive number.

2-1. TOKYO METROPOLITAN AREA

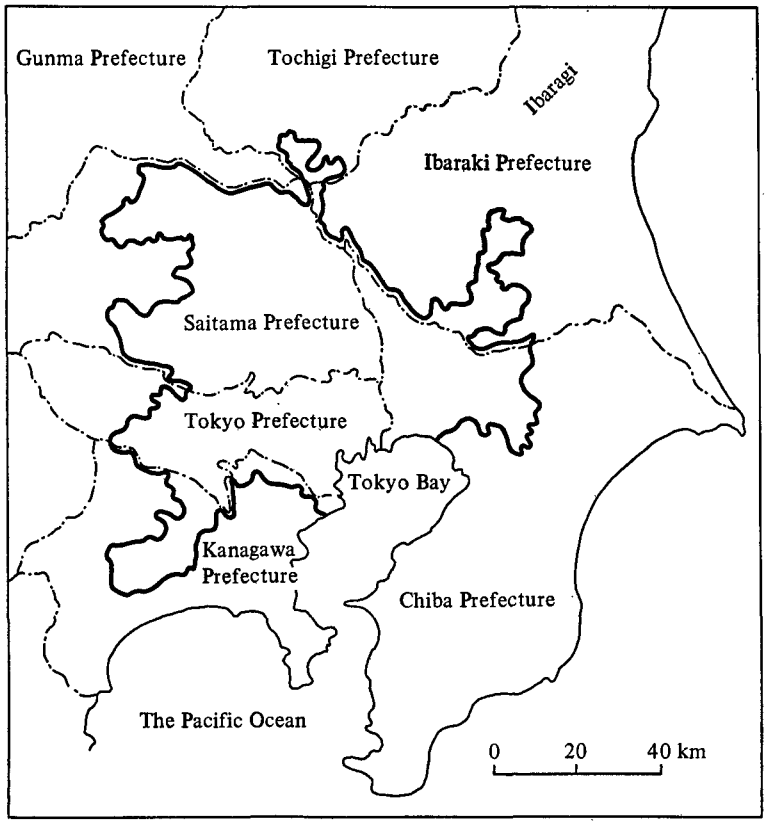


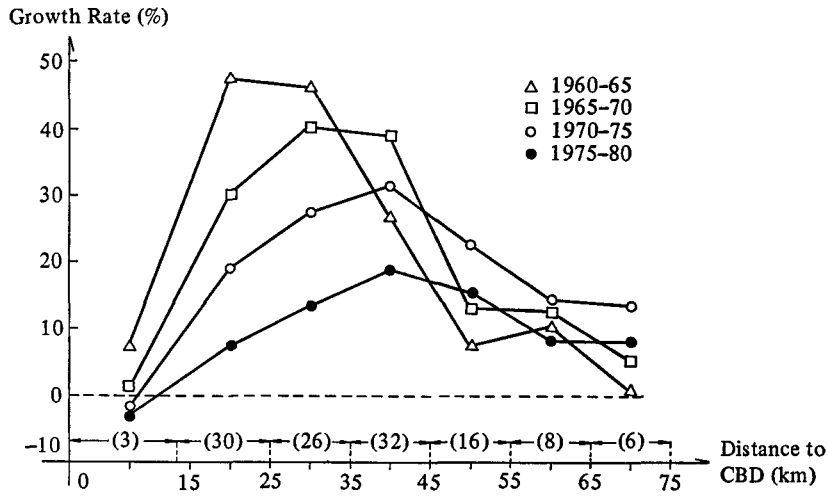
Fig. 2 Geographical Boundary of Tokyo FUC

The geographical boundary of Tokyo FUC is shown in Figure 2, while Table A-2-1 lists the names and code numbers of its 121 constituent localities. In Table A-2-2 are shown the distance and population data for those localities (sorted in ascending order of distance) for five-year intervals from 1960 to 1980. As can be seen from this table, Tokyo FUC had a population of around 21 million in 1980. Its largest locality is Tokyo Ku-area (Tokyo city) with an 8.3 million population in 1980, while its smallest locality is Motono village with a population of a little under five thousand in the same year. The average population of all the 121 localities in 1980 was 174 thousand. The distance from each locality to the CBD of Tokyo city[11], which is the central city of Tokyo FUC, ranges from 7.4 km for Tokyo city to 72.5 km for Fukaya city, the average distance turning out to be 36.2 km.

Regarding population changes in each of the localities of Tokyo FUC, Table A-2-3 furnishes the five-year growth rates for the four periods of 1960-65, 65-70, 70-75 and 75-80. In order to abstract the essence of what this table carries, let us produce Table 2 showing the five-year population growth rates by distance-zone. From this table, we can obtain Figure 3. Based on this figure, the following general tendencies can be remarked on the dynamic changes in the growth rate.

Table 2 Five-year Growth Rate (%) of Population by Distance Zone for Tokyo FUC

Distance Zone (km)	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
0 – 15	3	7.77	0.08	-1.62	-2.25
15 – 25	30	47.88	30.35	19.35	7.85
25 – 35	26	46.20	40.50	27.73	13.48
35 – 45	32	26.59	39.91	31.86	19.35
45 – 55	16	7.57	13.18	22.78	15.29
55 – 65	8	10.36	12.84	14.35	8.39
65 – 75	6	0.33	5.83	13.79	8.33
Tokyo FUC	121	18.34	13.64	10.83	5.48



(Note) The figure in the parentheses indicates the number of localities of its corresponding distance zone.

Fig. 3 Five-year Growth Rate of Population by Distance Zone for Tokyo FUC

(1) The peak of growth rate curve gradually shifted over time from inner distance-zones toward outer distance-zones with the peak corresponding to a 15-25 km distance-zone for the 1960-65 period, a 25-35 km distance-zone for the 1965-70 period and a 35-45 km distance-zone for the 1970-75 and 1975-80 periods.

(2) The maximum growth rate among all distance-zones for each five-year period decreased as time went on.

(3) The growth rate of inner distance-zones fell over time, while that of outer distance-zones increased until the 1965-70 period or the 1970-75 period and then began to fall.

(4) The growth rate curve looks almost bell-shaped for the 1970-75 period, while the curve for the 1975-80 period is slightly skewed toward outer distance-zones.

Such tendencies as stated above would suggest that Tokyo FUC had been in the late stage of centralization[12] during the 1960-80 period, or would perhaps indicate that it had already entered the early stage of suburbanization toward the end the 1970s. This hunch is likely to be verified to some extent through the values of ROXY index for Tokyo FUC shown in Table 3[13]. The ROXY index increased continuously from -120.12 for the 1960-65 period to 3.32 for 1975-80, with the negative sign turning positive around 1975, implying that the centralization in Tokyo FUC took place during 1960-75 with its speed decelerating[14]. In the second half of the 1970s, however, Tokyo FUC seems to have started to experience the first substage of suburbanization with the speed of suburbanization accelerating.

Table 3 ROXY Index for Tokyo FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Tokyo FUC	121	-120.12	-68.55	-19.79	3.32

Turning our attention to the spatial redistribution processes of population during 1960-80 in the region consisting of localities situated along the Chuo Line, which is one of the busiest commuting railway lines in Tokyo FUC and extends westwards, the five-year population growth rates of those localities in the Chuo Line region are as shown in Table A-2-5-(a), and the geographical boundary of the Chuo Line region is exhibited in Figure 4. Based on Table A-2-5-(a), we obtain the value of ROXY index for the Chuo Line region as listed in Table 4. The ROXY

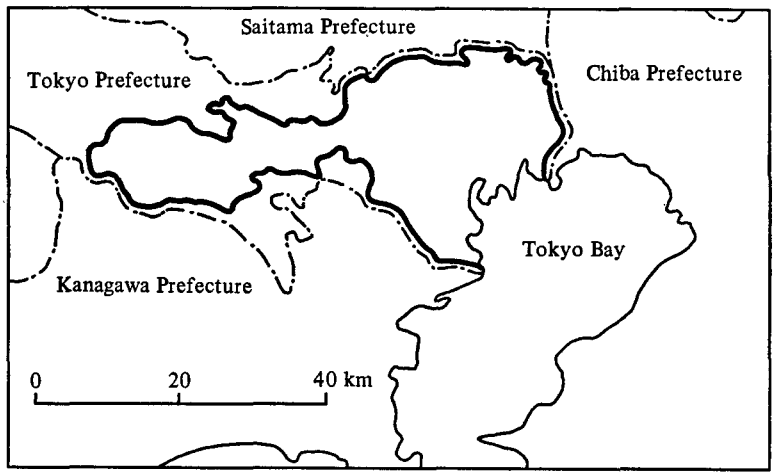


Fig. 4 Geographical Boundary of the Chuo Line Region

index for this region increased from 38.73 for the 1960-65 period to 53.72 for 1965-70. It then began to decrease to 51.86 for the 1970-75 period and 37.66 for 1975-80. This implies that the Chuo Line region experienced accelerating suburbanization during 1960-70 and that the speed of suburbanization in the region came to a climax in the late 1960s. After that the suburbanization process began to decelerate and this decelerating tendency of suburbanization continued throughout the 1970s.

Table 4 ROXY Index for Three Railway-line Regions in Tokyo FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Chuo Line Region	10	38.73	53.72	51.86	37.66
Takasaki Line Region	14	-73.18	7.96	45.86	38.94
Joban Line Region	9	-82.28	-25.47	16.05	36.05

Table 4 also shows the value of ROXY index obtained from Tables A-2-5-(b) and (c) for two other regions stretching along the Takasaki and Joban Lines both of which are among the major commuting railway lines in Tokyo FUC, just like the Chuo Line. The geographical bound-

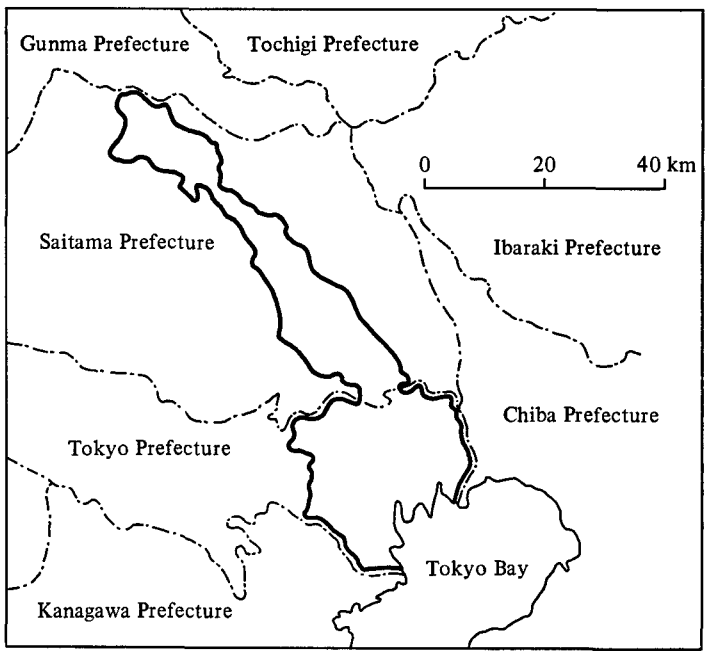


Fig. 5 Geographical Boundary of the Takasaki Line Region

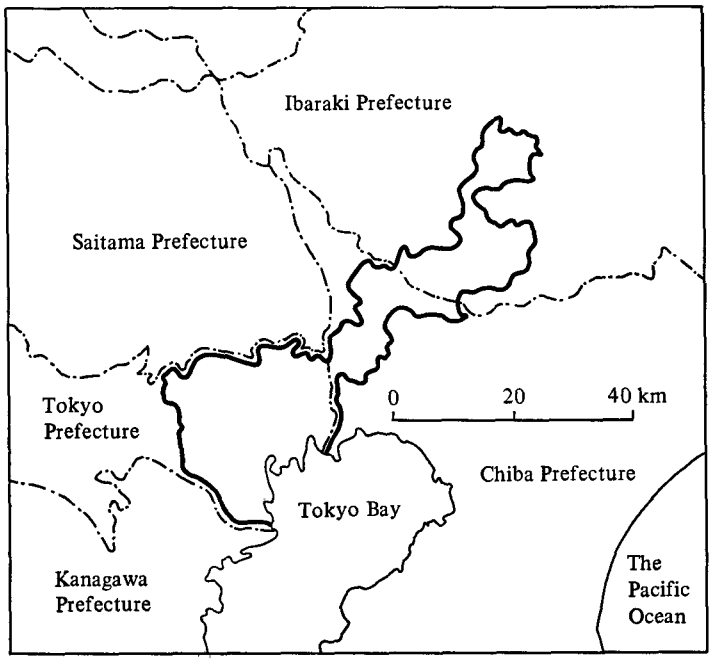


Fig. 6 Geographical Boundary of the Joban Line Region

aries of the two railway-line regions are exhibited in Figures 5 and 6 respectively. The ROXY index for the Takasaki Line region which extends northwards, increased from -73.18 for the 1960-65 period to 45.86 for the 1970-75 period with the negative sign turning positive around 1965. It then fell to 38.94 for the 1975-80 period. This implies that the Takasaki Line region was deceleratingly centralizing during 1960-65. After 1965, the region entered the stage of suburbanization with the speed of suburbanization accelerating. In the early 1970s, however, the region started to decelerate its suburbanization process.

For the Joban Line region which extends northeastwards, the ROXY index increased from -82.28 for the 1960-65 period to 36.05 for 1975-80 with the negative sign turning positive around 1970. This implies that the Joban Line region was in the stage of decelerating centralization in the 1960s, but also that the region reached the stage of suburbanization around 1970 with the suburbanization process accelerating throughout the 1970s.

2-2. OSAKA METROPOLITAN AREA

The geographical boundary of Osaka FUC is shown in Figure 7, while Table A-3-1 lists the names and code numbers of its 68 constituent localities. In table A-3-2 are shown the distance and population data for those localities (sorted in ascending order of distance) by five-year intervals from 1960 to 1980. From this table, we know that Osaka FUC had a population of

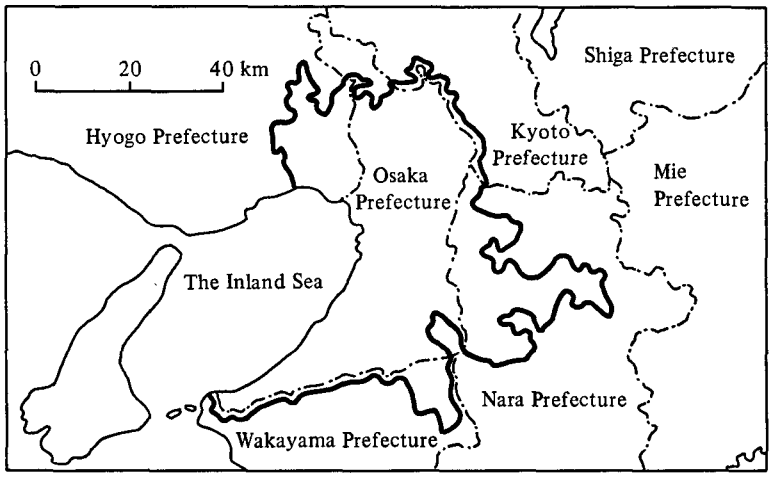


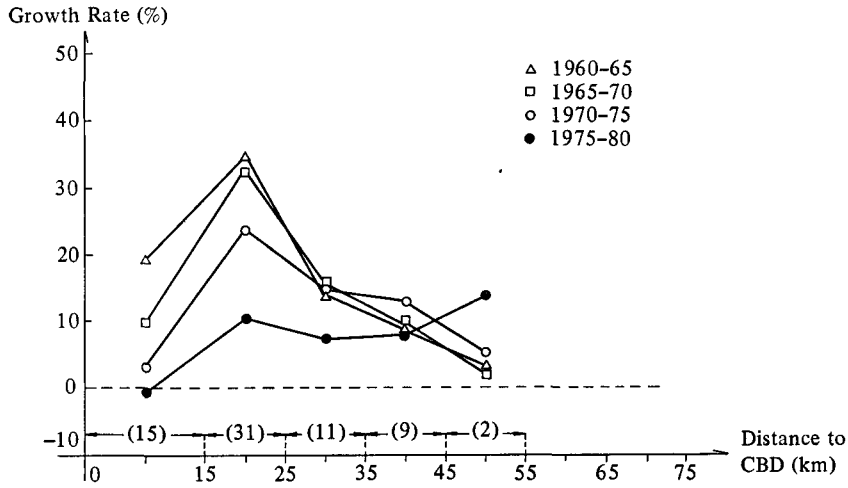
Fig. 7 Geographical Boundary of Osaka FUC

11 million in 1980. Its largest locality is Osaka city which had a 2.6 million population in 1980, while the smallest locality is Tajiri town with a 1980 population of 7.5 thousand. The average population size of all the 68 localities was 157 thousand in 1980. The distance from each locality to the CBD of Osaka city[15], which is the central city of Osaka FUC, ranges from 4.7 km for Osaka city to 52.9 km for Misaki town, the average distance turning out to be 22.4 km.

As to population changes in each locality of Osaka FUC, Table A-3-3 shows the five-year growth rates for the four periods of 1960-65, 65-70, 70-75 and 75-80. To get a basic idea of what this table tells us, it would be useful for us to produce Table 5 showing the five-year population growth rates by distance-zone. On the basis of this table we can draw Figure 8. From this figure, we can see the following tendencies in the dynamic changes in the growth rate.

Table 5 Five-year Growth Rate (%) of Population by Distance Zone for Osaka FUC

Distance Zone (km)	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
0 – 15	15	18.99	9.78	3.13	-0.75
15 – 25	31	34.35	32.82	23.83	10.28
25 – 35	11	14.19	14.42	14.35	7.0
35 – 45	9	8.50	9.02	12.47	8.49
45 – 55	2	2.77	2.06	4.86	13.62
Osaka FUC	68	21.15	14.78	9.02	3.05



(Note) The figure in the parentheses indicates the number of localities of its corresponding distance zone.

Fig. 8 Five-year Growth Rate of Population by Distance Zone for Osaka FUC

(1) The gravity center of "population growth rate" gradually shifted over time from inner distance-zone toward outer distance-zone during 1960-80.

(2) The maximum growth rate among all distance-zones for each five-year period decreased as time went on.

(3) The growth rate of inner distance-zones fell over time, while that of outer distance-zones, except the farthest distance-zone, increased until the 1965-70 period and then began to fall.

(4) The growth rate of the farthest distance-zone showed a generally increasing trend over time.

(5) The growth rate curve for the 1970-75 period is slightly skewed toward inner distance zones, while the curve for the 1975-80 period shows a moderate increasing trend over distance.

These tendencies suggest that Osaka FUC, like Tokyo FUC, had been in the late stage of centralization until the mid-1970s. By use of the values of ROXY index shown in Table 6[16] for

Table 6 ROXY Index for Osaka FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Osaka FUC	68	-115.99	-78.53	-17.54	12.57

Osaka FUC, such tendencies as mentioned above could be restated as follows. That is, the ROXY index increased continuously from -115.99 for the 1960-65 period to 12.57 for 1975-80, with the negative sign turning positive around 1975. This implies that Osaka FUC was in the stage of decelerating centralization for the 1960-75 period; however, Osaka FUC entered the early stage of suburbanization in the second half of the 1970s with the speed of suburbanization accelerating after that.

Now let us turn our eyes to the spatial redistribution processes of population in three major railway-line regions of Osaka FUC. They are the Sanyo Line, the Tokaido Line and the Hanwa Line regions, whose geographical boundaries are exhibited in Figures 9 through 11, and their ROXY index in shown in Table 7 which can be obtained from Tables A-3-5-(a) through (c).

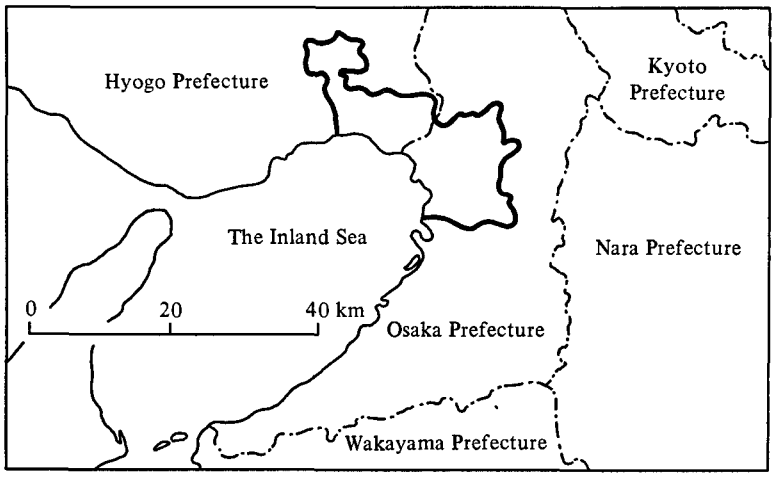


Fig. 9 Geographical Boundary of the Sanyo Line Region

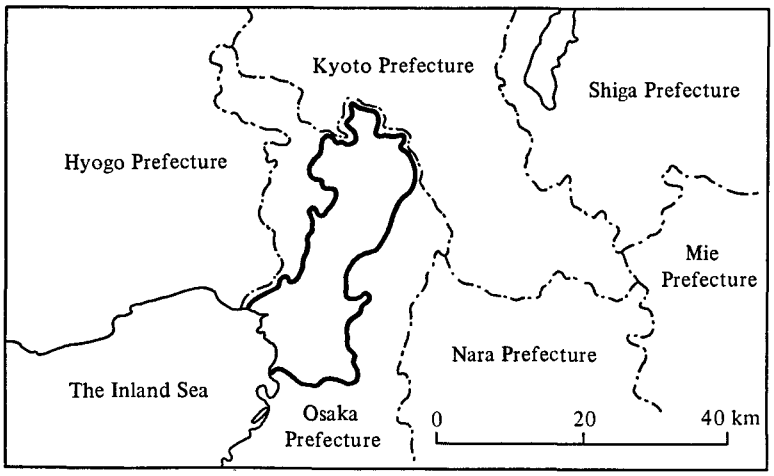


Fig. 10 Geographical Boundary of the Tokaido Line Region

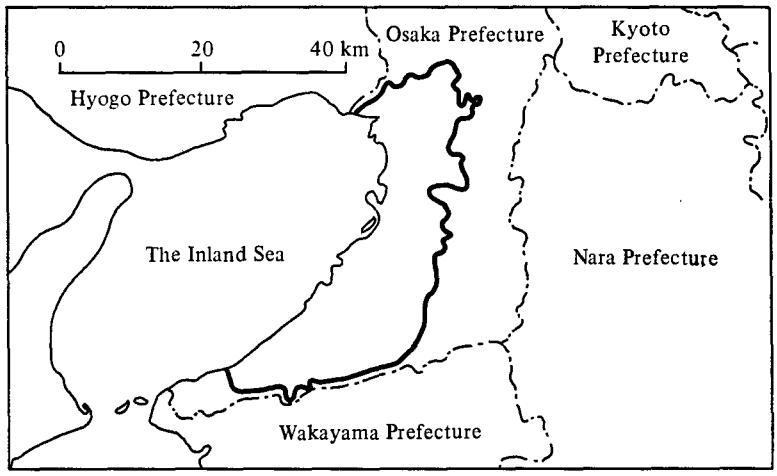


Fig. 11 Geographical Boundary of the Hanwa Line Region

Table 7 ROXY Index for Three Railway-line Regions in Osaka FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Sanyo Line Region	4	32.04	55.99	50.26	39.44
Tokaido Line Region	6	45.33	108.69	108.51	26.12
Hanwa Line Region	12	-12.44	6.73	47.18	45.52

For the Sanyo Line region which extends westwards, the ROXY index increased from 32.04 for the 1960-65 period to 55.99 for 1965-70. It then began to decrease to the values of 50.26 for the 1970-75 period and 39.44 for 1975-80. This implies that the Sanyo Line region was acceleratingly suburbanizing throughout the 1960s. After 1970, nevertheless, the Sanyo Line region entered the stage of decelerating suburbanization.

For the Tokaido Line region which extends northeastwards, the ROXY index increased from 45.33 for the 1960-65 period to 108.69 for 1965-70. It then fell to 108.51 for the 1970-75 period and 26.12 for the 1975-80 period. This implies that the Tokaido Line region was acceleratingly suburbanizing in the 1960s. After 1970, however, the Tokaido Line region entered the stage of decelerating suburbanization.

The value of ROXY index for the Hanwa Line region which extends southwards increased from -12.44 for the 1960-65 period to 47.18 for 1970-75, with the negative sign turning positive around 1965. It then fell to 45.52 for the 1975-80 period. This implies that the Hanwa

Line region was deceleratingly centralizing in the first half of the 1960s to enter the suburbanization stage in the mid-1960s. After that, the Hanwa Line region was acceleratingly suburbanizing until the early 1970s. In the second half of the 1970s, however, the region entered the stage of decelerating suburbanization.

2-3. NAGOYA METROPOLITAN AREA

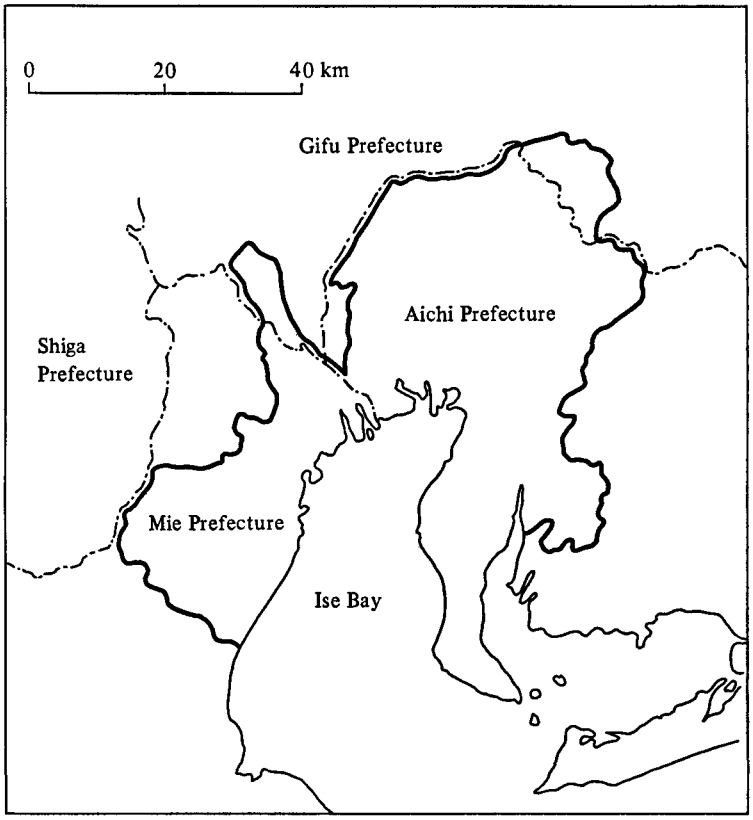


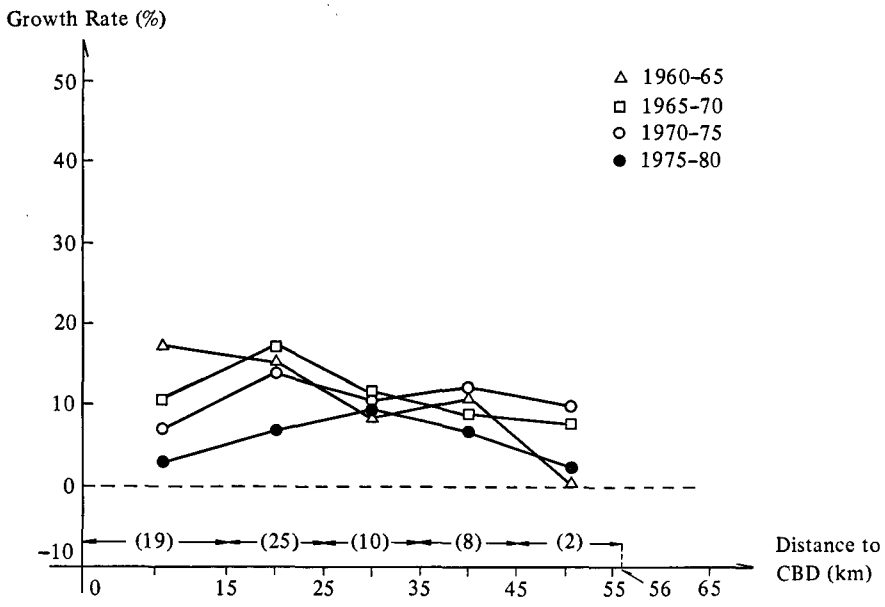
Fig. 12 Geographical Boundary of Nagoya FUC

The geographical boundary of Nagoya FUC is shown in Figure 12, while Table A-4-1 lists the names and code numbers of its 64 constituent localities. Table A-4-2 furnishes the distance and population data for those localities (sorted in ascending order of distance) by five-year intervals from 1960 to 1980. This table tells us that Nagoya FUC had a population of 5.4 million in 1980. Its largest locality is Nagoya city which had a 2.1 million population in 1980, while the smallest locality is Jushiyama village with a 1980 population of 5.7 thousand. The average population size of all the 64 localities was 85 thousand in 1980. The distance from each locality to the CBD of Nagoya city[17] which is the central city of Nagoya FUC, ranges from 3.8 km for Nishibiwajima town to 55.2 km for Kawage town, the average distance turning out to be 21.3 km.

Population changes of each locality in Nagoya FUC are shown in Table A-4-3 in terms of the five-year growth rate for the four periods of 1960-65, 65-70, 70-75 and 75-80. From this table, we construct Table 8 showing the five-year population growth rates by distance-zone. Based on this table, we can draw Figure 13. This Figure shows us the following general tendencies of the dynamic changes in the growth rate.

Table 8 Five-year Growth Rate (%) of Population by Distance Zone for Nagoya FUC

Distance Zone (km)	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
0 – 15	19	17.60	10.74	7.24	2.71
15 – 25	25	15.14	17.47	14.65	7.00
25 – 35	10	8.47	11.14	10.69	9.08
35 – 45	8	11.45	9.66	12.22	7.04
45 – 56	2	0.62	8.09	10.11	2.12
Nagoya FUC	64	15.33	12.22	9.89	4.81



(Note) The figure in the parentheses indicates the number of localities of its corresponding distance zone.

Fig. 13 Five-year Growth Rate of Population by Distance Zone for Nagoya FUC

(1) The gravity center of "population growth rate" gradually shifted over time from inner distance-zone toward outer-distance zone during 1960-80.

(2) The maximum growth rate among all distance zones for each five-year period decreased as time went on.

(3) The growth rate of the 0-15 km distance-zone fell over time, while for the 15-25 km and 25-35 km distance zones the maximum growth rate appeared during the period of 1965-70. For the 35-45 km and 45-56 km distance zones, the maximum growth rate took place during the 1970-75 period.

(4) The growth rate curves for the 1960-65, 1965-70 and 1970-75 periods are skewed toward inner distance zones, while the growth rate curve for the 1975-80 period looks almost symmetrical.

These tendencies suggest that Nagoya FUC was in the late stage of centralization throughout the twenty-year period 1960-80, but that it perhaps nearly reached the turning point from the centralization stage to the suburbanization stage around 1980[18]. Investigating the spatial redistribution process of population in Nagoya FUC by means of the values of ROXY index, Table 9[19] tells us that the ROXY index increased continuously from -77.76 for the 1960-65 period to -5.22 for 1975-80. This implies that in Nagoya FUC the centralization process took place during the whole two-decade period after 1960 with the speed of centralization decelerating, but that the stage of centralization was almost over toward 1980.

Table 9 ROXY Index for Nagoya FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Nagoya FUC	64	-77.76	-72.05	-28.79	-5.22

In order to get a primary insight into the spatial redistribution processes of population in the railway-line regions of Nagoya FUC, let us examine the Kansai Line[20], the Tokaido Line (North-bound) and the Tokaido Line (South-bound) regions, whose geographical boundaries are exhibited in Figures 14 through 16. Table 10 shows their ROXY index, which can be obtained on the basis of Tables A-4-5-(a) through (c). For the Kansai Line region which extends westwards, the ROXY index increased from 1.58 for the 1960-65 period to 48.97 for 1970-75. It then fell to 23.22 for the 1975-80 period. This implies that the Kansai Line region experienced accelerating suburbanization for approximately fifteen years after 1960, with the

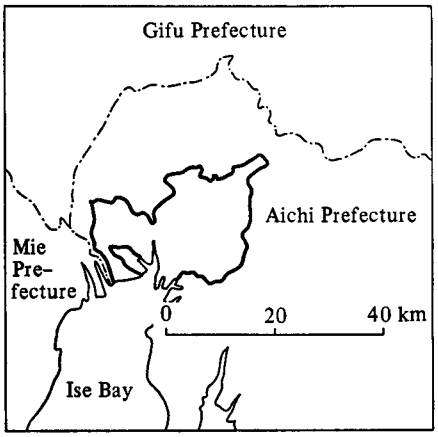


Fig. 14 Geographical Boundary of the Kansai Line (Up to Kiso River) Region

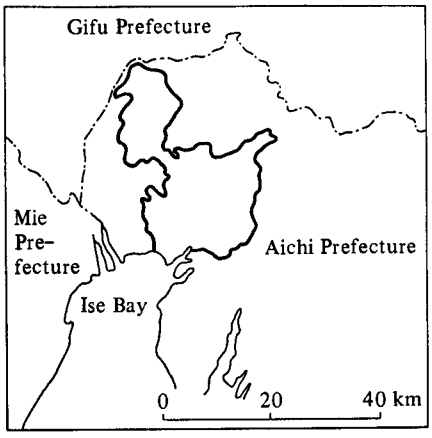


Fig. 15 Geographical Boundary of the Tokaido Line (North-bound) Region

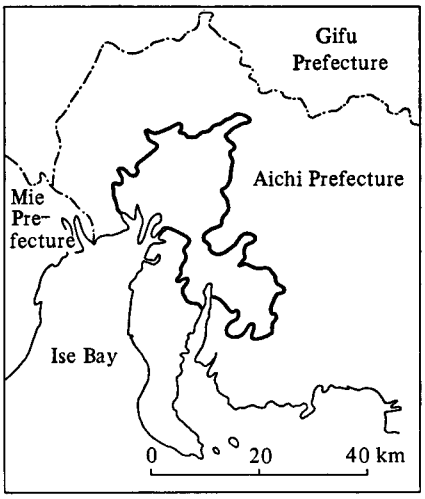


Fig. 16 Geographical Boundary of the Tokaido Line (South-bound) Region

Table 10 ROXY Index for Three Railway-line Regions in Nagoya FUC

Spatial Unit	Number of Localities	Period			
		1960-65	1965-70	1970-75	1975-80
Kansai Line (Up to Kiso River) Region	5	1.58	23.73	48.97	23.22
Tokaido Line (North-bound) Region	7	-21.96	-8.28	24.24	34.93
Tokaido Line (South-bound) Region	6	2.39	43.10	34.96	20.52

speed of suburbanization coming to a climax in the early 1970s. After that the speed of suburbanization began to decelerate and this tendency of deceleration continued during the second half of the 1970s.

For the Tokaido Line (North-bound) region which extends northwards, the ROXY index increased continuously from -21.96 for the 1960-65 period to 34.93 for 1975-80 with the negative sign turning positive around 1970. This implies that the Tokaido Line (North-bound) region experienced decelerating centralization in the 1960s. Around 1970, the spatial redistribution process of population in the region reached the suburbanization stage with the speed of suburbanization accelerating throughout the 1970s.

The value of ROXY index for the Tokaido Line (South-bound) region which extends southwards increased from 2.39 for the 1960-65 period to 43.10 for 1965-70. It then fell to 34.96 for the 1970-75 period and 20.52 for 1975-80. This implies that the Tokaido Line (South-bound) region was in the stage of suburbanization for the whole two decades from 1960 through 1980, with the speed of suburbanization accelerating in the 1960s and then decelerating in the 1970s.

3. COMPARISON OF SPATIAL CYCLE STAGES

3-1. JAPANESE URBAN SYSTEM AS COMPARED WITH THREE LARGEST FUC's

From Tables 3, 6, 9 and A-1-1, we obtain Table 11 showing the changes in the value of

Table 11 ROXY Index for the Urban System of Japan and Three Largest FUCs

	Spatial System	Number of Metropolitan Areas (FUCs)	Period			
			1960-65	1965-70	1970-75	1975-80
Inter-metropolitan Analysis	Japanese Urban System	86	121.04	84.49	39.50	0.48

	Spatial Unit	Number of Localities	Period			
			1960-65	1965-70	1970-75	1975-80
Intra-metropolitan Analysis	Tokyo FUC	121	-120.12	-68.55	-19.79	3.32
	Osaka FUC	68	-115.99	-78.53	-17.54	12.57
	Nagoya FUC	64	- 77.76	-72.05	-28.79	-5.22

(Note) See Note-4 of Table 1 for the relationship between the sign of the value of ROXY index and agglomeration phenomenon.

ROXY index for the urban system of Japan as well as for Tokyo, Osaka and Nagoya FUCs. The ROXY index for the urban system of Japan was positive in its sign but decreased continuously during the 1960-80 period. This implies that the Japanese urban system experienced a decelerating concentration of population throughout the entire two decades from 1960. However, the ROXY index for the 1975-80 period was close to zero, which implies that the stage of decelerating concentration nearly came to an end toward 1980 and that the Japanese urban system would probably reach the first stage of deconcentration of population in the 1980s as explained in Appendix 1. At the same time, based on Table 11, the following three observations can be made.

(i) The ROXY index for the urban system of Japan has a crystal-clear negative correlation with that for each of the three largest FUCs.

(ii) It seems that the period when the sign of ROXY index for the urban system turns from positive to negative probably almost corresponds to the period when the sign of ROXY index for each of the three largest FUCs turns from negative to positive.

(iii) The ROXY index for each of Tokyo and Osaka FUCs already turned out to be positive during the 1975-80 period.

The aforementioned would hint to us that the value of ROXY index for Tokyo and Osaka FUCs could perhaps serve as a "leading indicator (negatively correlated)" for the ROXY index of the urban system of Japan. Put another way, through looking at the changes in the value of ROXY index for Tokyo and Osaka FUCs, we might probably be able to know five or ten years in advance, for example, (i) the time when the speed of deconcentration of population in the Japanese urban system comes to a climax, or (ii) the time when in future the population redistribution processes of the Japanese urban system regress from the stage of deconcentration into the stage of concentration again.

3-2. COMPARISON OF SUBURBANIZATION AMONG THREE LARGEST FUC's

From Tables 3, 4, 6, 7, 9 and 10, we can construct Table 12. Based on this table, we can compare the degree of "suburbanization advancement" in the context of spatial cycle scheme (i) among Tokyo, Osaka and Nagoya FUCs, (ii) among the three railway-line regions in Tokyo FUC, (iii) among the three railway-line regions in Osaka FUC, and (iv) among the three railway-line regions in Nagoya FUC. Let us now, for the purpose of determining the rank of "suburbanization advancement" in the 1975-80 period for each spatial unit, tentatively introduce the following four criteria[21] as well as the dominancy principle that the first criterion is dominant over the second one, the second one dominant over the third one, and so on;

(i) Suburbanization stage for the 1975-80 period (DS is more advanced than AS in the stage of suburbanization, and AS is more advanced than DC.),

(ii) The time when the centralization stage ends and the suburbanization stage starts (The earlier the time is, the more advanced the suburbanization stage is.),

(iii) The time when the speed of suburbanization is maximized (The earlier the time is, the more advanced the suburbanization stage is.), and

(iv) The value of ROXY index for the 1975-80 period (For the stage of accelerating suburbanization, the higher value corresponds to the more advanced stage of suburbanization.).

Table 12 Rank of Advancement in Suburbanization: Tokyo, Osaka and Nagoya FUCs, and Their Railway-line Regions

Spatial Unit	Number of Localities	PCS	PZS	Suburbanization Stage for 1975-80	Value of ROXY Index for 1975-80	Rank of Suburbanization Advancement
Tokyo FUC	121	1975	Y	AS	3.32	2
Osaka FUC	68	1975	Y	AS	12.57	1
Nagoya FUC	64	Z	Z	DC	-5.22	3
Chuo Line Region	10	V	W	DS	37.66	1
Takasaki L. Region	14	1965	X	DS	38.94	2
Joban Line Region	9	1970	Y	AS	36.05	3
Sanyo Line Region	4	V	W	DS	39.44	1
Tokaido Line Region	6	V	W, X	DS	26.12	2
Hanwa Line Region	12	1965	X	DS	45.52	3
Kansai Line (Up to Kiso River) Region	5	V	X	DS	23.22	2
Tokaido Line (Northbound) Region	7	1970	Y	AS	34.93	3
Tokaido Line (Southbound) Region	6	V	W	DS	20.52	1

(Note)

1. DC : Decelerating Centralization
2. AS : Accelerating Suburbanization
3. DS : Decelerating Suburbanization
4. PCS : Turning Point from Centralization Stage to Suburbanization Stage
5. PZS : Zenith Point of Suburbanization Speed
6. V : Before or around 1960
7. W : 1965-70
8. X : 1970-75
9. Y : 1975-80
10. Z : 1975-80 or not yet arrived
11. Rank of "Suburbanization Advancement" was determined based on PCS and PZS except for the comparison among Tokyo, Osaka and Nagoya FUCs. We determined the rank among these three FUCs based on the suburbanization stage for 1975-80, PCS, PZS and the value of ROXY index for 1975-80 as well.

According to the above criteria, we can get the last column of Table 12.

The table tells us that, among the three largest FUCs, Osaka FUC, which had already reached the stage of suburbanization in the middle of the 1970s, was in advance of the other two FUCs along the path of spatial cycle scheme. Tokyo FUC which also reached the stage of suburbanization in the middle of the 1970s, was slightly behind Osaka FUC since its value of ROXY index for the 1975-80 period was smallar than that of Osaka FUC. However, Tokyo FUC has been ahead of Nagoya FUC which was still experiencing decelerating centralization during the 1975-80 period.

3-3. COMPARISON ON SUBURBANIZATION AMONG RAILWAY-LINE REGIONS

Table 12 also tells us that, among the three railway-line regions in Tokyo FUC, the Chuo Line region whose suburbanization phenomenon was decelerating, was in the most advanced phase along the path of spatial cycle scheme during the 1975-80 period. Next comes the Takasaki Line region; this region was ahead of the Joban Line region which was still in the stage of accelerating suburbanization during the same period. It is often mentioned that, geographically speaking, the Tokyo metropolitan area has been developed clockwise in general. Interestingly enough to notice, it is clearly shown by our analysis that Tokyo FUC has been suburbanizing clockwise; the suburbanization first started before or around 1960 in the Chuo Line region extending westwards, then the Takasaki Line region extending northwards reached the stage of suburbanization around 1965, and after that around 1970 the suburbanization started in the Joban Line region extending northeastwards[22].

In Osaka FUC, the three railway-line regions were all in the stage of decelerating suburbanization during the 1975-80 period. However, the Hanwa Line region reached the stage of suburbanization around 1965, while the suburbanization started in the Sanyo Line and the Tokaido Line regions before or around 1960. Accordingly, it can be said that the Hanwa Line region has been behind the other two railway-line regions along the path of spatial cycle scheme. Between the other two railway-line regions, the Sanyo Line region was at the zenith of the speed of suburbanization in the second half of the 1960s, while the speed came to a climax around 1970 for the Tokaido Line region. This would suggest to us that the Sanyo Line region has been slightly shead of the Tokaido Line region in the phase of suburbanization[23].

As to the three railway-line regions in Nagoya FUC, both the Kansai Line and the Tokaido Line (South-bound) regions which reached the suburbanization stage before or around 1960 were in the stage of decelerating suburbanization during the 1975-80 period, while the Tokaido Line (North-bound) region was still in the stage of accelerating suburbanization during the same period. Hence, the Tokaido Line (North-bound) region has been behind the other two railway-line regions in the phase of suburbanization. Between the Kansai Line region and the Tokaido Line (South-bound) region, the latter experienced the zenith of the speed of suburbanization during the 1965-70 period while the former did during 1970-75. In addition, the Tokaido Line (South-bound) region had a lower value of ROXY index for the 1975-80 period than the Kansai

Line region. Therefore, it could perhaps be acceptable for us to conclude that the Tokaido Line (South-bound) region has been suburbanizing ahead of the Kansai Line region.

If we now dare to roughly classify the nine railway-line regions into three groups without regard for the difference in FUC to which each railway-line region belongs, then we get the following groups concerning the degree of suburbanization advancement.

(i) The early suburbanizing regions:

Chuo Line region (in Tokyo FUC)
Sanyo Line region (in Osaka FUC)
Tokaido Line region (in Osaka FUC)
Tokaido Line (South-bound) region (in Nagoya FUC)

The clustering criteria for this group are (a) that the phenomenon of decelerating suburbanization was observed during the 1975-80 period, (b) that the suburbanization started before or around 1960, and (c) that the suburbanization speed was at its maximum before or around the 1970s.

(ii) The moderately suburbanizing regions:

Takasaki Line region (in Tokyo FUC)
Hanwa Line region (in Osaka FUC)
Kansai Line region (in Nagoya FUC)

The clustering criteria for this group are (a) that the phenomenon of decelerating suburbanization was observed during the 1975-80 period, (b) that the suburbanization started before or around 1965, and (c) that the suburbanization speed was at its maximum during the 1970-75 period.

(iii) The late suburbanizing regions:

Joban Line region (in Tokyo FUC)
Tokaido Line (North-bound) region (in Nagoya FUC)

The clustering criterion for this group is that the phenomenon of accelerating suburbanization was observed during the 1975-80 period.

The above classification is diagrammatically presented in Figure 17[24] where the path of the spatial cycle movement is shown for each spatial unit in terms of the value of ROXY index and its marginal change[25].

4. CONCLUSION

Examining the speed of suburbanization for the three FUCs and nine railway-line regions in this study, we have somehow grasped the basic dynamic characteristics of the phenomenon of suburbanization including a rough idea on when the suburbanization started in each spatial unit and in what stage of suburbanization each spatial unit was during the 1975-80 period. At the same time, this study has provided solid empirical evidence for the existence of statistical regularities supporting the spatial cycle hypothesis the original scheme of which was developed by Klaassen et al. (1981)[26]. In addition, this study has demonstrated that the method of ROXY index analysis seems to be reasonably useful for some types of spatial analyses and perhaps for

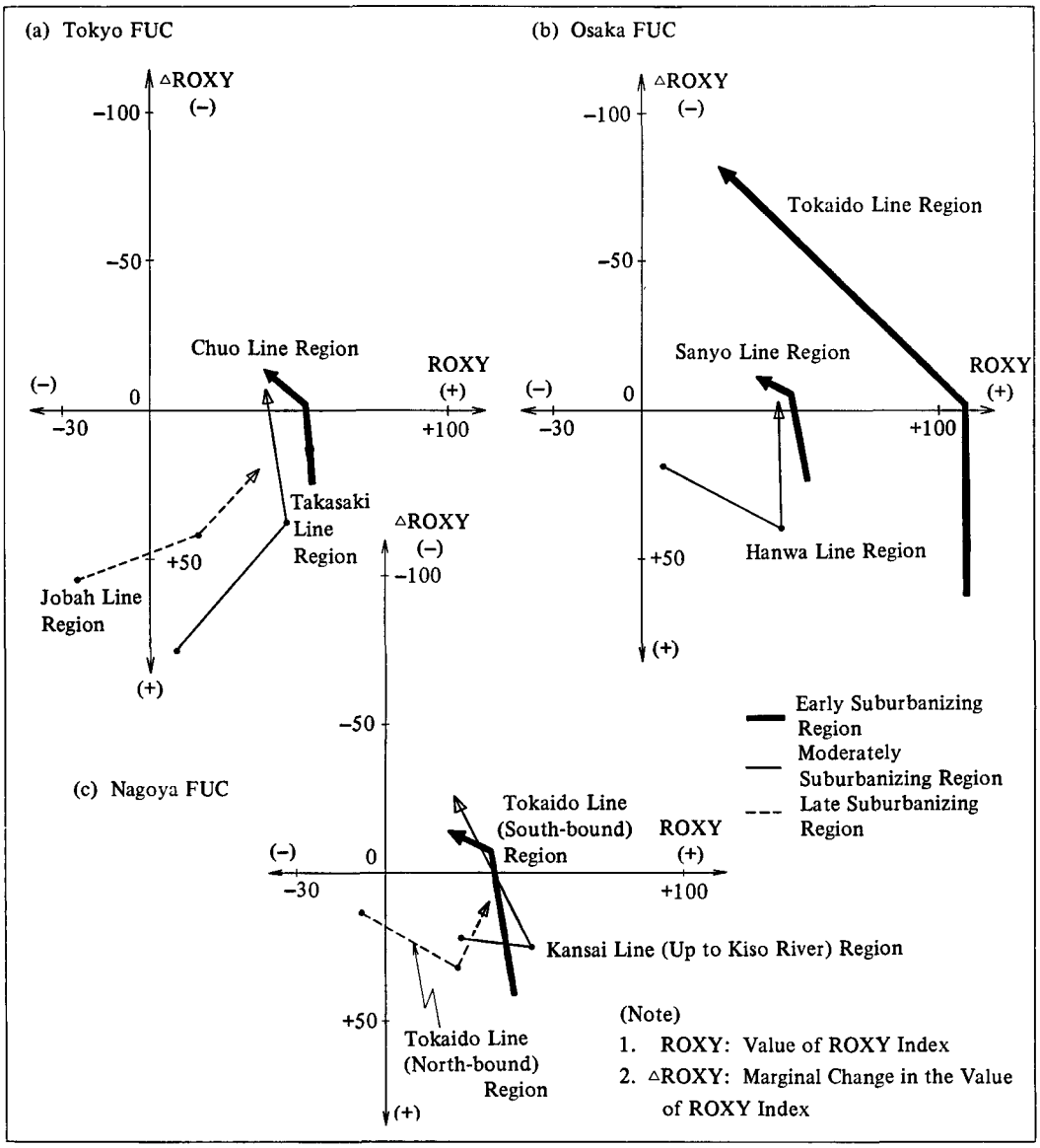


Fig. 17 Path of Spatial Cycle Movement

some sorts of hierarchical analyses too. This study has also shown that the ROXY index method would be worth further development[27] and wider application[28].

On the top of that, the results of our study would suggest to us that more substantial researches should be carried out on large metropolitan areas in order to get a keener insight into the dynamic changes of the urban system of metropolitan areas and that, vice versa, research into the urban system would produce valuable information about the dynamic changes of large metropolitan areas.

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NOTES

1) Strictly speaking, the ROXY index defined in this manner, is the ROXY index (Type II) which is a slightly revised version of the original (Type I) developed by Kawashima (1982). Table N-1 describes, for the inter-metropolitan spatial redistribution processes of population, the implications of the value of ROXY index and those of the direction of changes in the value. For a further discussion of the basic features of ROXY index, see Kawashima (1985).

Table N-1 Implications of ROXY Index for Inter-metropolitan Spatial Redistribution Processes of Population (Weighting Factor: Population of Metropolitan Area)

(i) Value of ROXY Index	(ii) Inter-metropolitan Spatial Redistribution Pattern of Population Shares	(iii) Direction of Changes in Value of ROXY Index	(iv) Speed of Spatial Redistribution of Population
ROXY > 0	Concentration of Population (Agglomeration of Population)	→ (1) / → (2) / → (3)	(1) Accelerating (2) Stabilizing (3) Decelerating
ROXY = 0	Symmetric Growth or Decline of Population (viz. BGD, BSGD or CSGD of Population)	0.0 → 0.0	Can not be specified
ROXY < 0	Deconcentration of Population (Dispersion of Population)	→ (1) / → (2) / → (3)	(1) Decelerating (2) Stabilizing (3) Accelerating

(Note)

1. BGD: Balanced Growth or Decline (Namely, the growth rate curve is nearly flat, reflecting the constant share of population over different population-size groups of metropolitan areas.)
2. BSGD: Bell-shaped Growth or Decline (Namely, the growth rate curve is bell-shaped, reflecting the "medianization" of population over population-size groups. This "medianization" means increase in population share by medium population-size groups of metropolitan areas and, at the same time, decrease in population share by small and large population-size groups of metropolitan areas.)
3. CSGD: Cup-shaped Growth or Decline (Namely, the growth rate curve is cup-shaped, reflecting the "bipolarization" of population over population-size groups. This "bipolarization" means increase in population share by small and large population-size groups of metropolitan areas and, at the same time, decrease in population share by medium population-size groups of metropolitan areas.)

2) The boundaries of FUCs have been delineated by T. Kawashima and N. Glickman. They are those boundaries as of 1970 and fixed over time. See Kawashima (1982) for the details of the definition of FUCs.

3) Standard definitions of metropolitan statistical areas in the U.S. were first issued in 1949 by the then Bureau of the Budget which was the predecessor of the U.S. Office of Management and Budget (OMB), under the designation of "Standard Metropolitan Areas (SMAs)". The term was changed to "Standard Metropolitan Statistical Areas (SMSAs)" in 1959. Effective June 30, 1983, OMB changed the basic term from SMSA to "Metropolitan Statistical Areas (MSAs)" and revised the geographic definitions of many individual metropolitan areas; some new areas were defined, and some areas were redesignated as "Primary Metropolitan Statistical Areas (PMSAs)" or "Consolidated Metropolitan Statistical Areas (CMSAs)." On October 12, 1984, there were 261 MSAs, as well as 21 CMSAs comprising 73 PMSAs (including 4 MSAs, 1 CMSA, and 2 PMSAs in Puerto Rico). For further explanation, see U.S. Bureau of the Census (1984, pp. 873-4).

4) Kawashima (1985).

5) The concentration of population to larger FUCs means here that the population growth ratios of larger FUCs are greater than those of smaller FUCs, and would not necessarily mean either that the growth ratios of larger FUCs are greater than unity or that the growth ratios of smaller FUCs are less than unity. The population growth ratio for the period between year t and year t+1 is defined as $X_{i,t+1}/X_{i,t}$ where $X_{i,t}$ indicates the population level of metropolitan area i in year t.

6) The same study additionally includes the ROXY index analyses for other three kinds of urban systems; (i) an urban system which is composed of central cities of twenty-four FUCs among the thirty largest FUCs, (ii) an urban system which is composed of the thirty largest

SMSAs and (iii) an urban system which is composed of the central cities of twenty-nine SMSAs among the thirty largest SMSAs. Appendix 1 summarizes the results of the study for these three urban systems as well as for the two urban systems touched upon in the text.

7) The disurbanization stage here means the phase of relative disurbanization which is associated with the lower growth rate of population in large metropolitan areas as compared with the national average. On the other hand, the absolute disurbanization phenomenon for an urban system is closely associated with the net decline of population in large metropolitan areas. For a discussion of the concepts of absolute and relative disurbanization, see Kawashima (1986).

8) For the basic arguments to support this future prospect, see Kawashima (1985 and 1986).

9) Suppose that we have a regression equation;

$$r = \alpha + \beta \times d + e$$

where r : population growth ratio
d : distance from central business district
α, β : regression coefficients
e : error term.

Then, the ordinary least squares (OLS) estimate of β is equal to;

$$\frac{n\sum_{i=1}^{n} d_i r_i^{t,t+1} - \sum_{i=1}^{n} d_i \times \sum_{i=1}^{n} r_i^{t,t+1}}{n\sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2}$$

Therefore, we can point out the following relationships between the value of ROXY index and the coefficient b which is the OLS estimate of β.

(i) The value of ROXY index turns out to be greater than, equal to, or less than zero if and only if the value of the coefficient b is greater than, equal to, or less than zero respectively.

(ii) The ROXY index is "scale-invariant" (or physically dimensionless), viz. the value of ROXY index is independent of the scale-unit to measure d. In contrast with this, the coefficient b is not "scale-invariant" at all because it has the dimension of $[r \times d^{-1}]$ which turns out to be $[d^{-1}]$ since r is a dimensionless variable. In other words, the coefficient b varies depending on the scale-unit applied for d.

(iii) In the ROXY index, the distance is automatically normalized. This characteristic is exemplified by the value of ROXY index turning out to be 144.93 for both of the following hypothetical spatial units A and B each of which consists of two localities;

(a) Spatial unit A: The population growth ratio and the distance for its first locality are 1.1 and 5 km respectively, while the second locality's growth ratio and distance are 1.2 and 10 km respectively, and

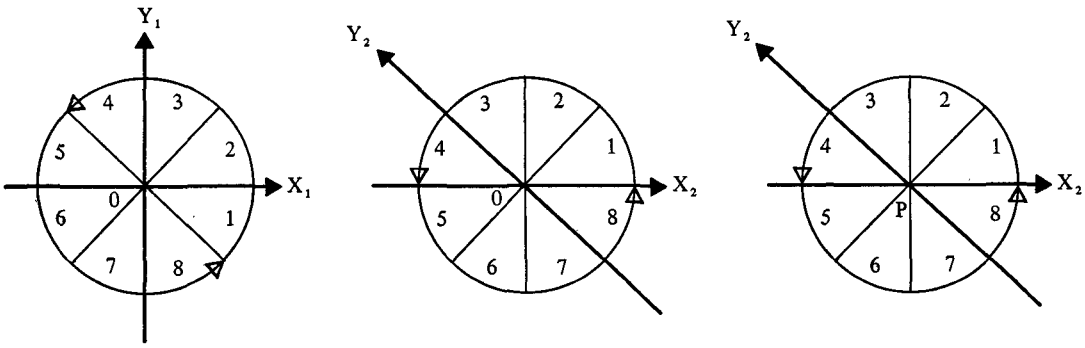
(b) Spatial unit B: The population growth ratio and the distance of its first locality

are 1.1 and 10 km respectively, while the second locality's growth ratio and distance are 1.2 and 20 km respectively.

In the coefficient b, the distance is not automatically normalized. And therefore, as to the above numerical example, the coefficient b turns out to be 0.02 for the spatial unit A and 0.01 for the spatial unit B.

(iv) In case all d_i's are identical to each other, the value of ROXY index is zero (unless all d_i's are zero or all $r_i^{t,t+i}$'s, are zero under which the index can not be defined), while the coefficient b can not be determined at all. In case the d_i are closely bunched, the value of ROXY index remains stable in the vicinity of zero (unless all d_i's are zero or all $r_i^{t,t+1}$'s are zero under which the index can not be defined) but the coefficient b becomes utterly unstable in the sense that a slight change in the values of d_i's would possibly cause an extremely large positive value of the coefficient b to shift into an extremely large negative value and vice versa.

10) This version of a spatial cycle concept has been constructed on the basis of the "type-β spatial cycle scheme" and "type-γ spatial cycle scheme" both of which are diagrammatically illustrated by Figures N-1(b) and (c) respectively. Note that stages of decelerating centralization,



(a) Type-α Scheme (b) Type-β Scheme (c) Type-γ Schema

(Note) 1. X_1 : Population Change in Central City
2. Y_1 : Population Change in Suburbs
3. X_2 : Population Growth Rate of Central City
4. Y_2 : Population Growth Rate of Metropolitan Area
5. z : Average Growth Rate of National Total Population
6. Coordinates of Point P: (z, z)
7. Number in Each Fan-shaped Segment: Substage Number
   Urbanization Stage : Substages 1 and 2
   Suburbanization Stage : Substages 3 and 4
   Disurbanization Stage : Substages 5 and 6
   Reurbanization Stage : Substages 7 and 8

Fig. N-1 Three Types of Spatial Cycle Schemes

accelerating suburbanization, decelerating suburbanization and accelerating urbanization in Figure 1, would respectively correspond to the stages of urbanization, suburbanization, disurbanization and reurbanization in Figure N-1(b). In developing type-β and type-γ spatial cycle schemes, the author has directly benefited from Klaassen et al. (1981) which originally conceived the basic framework of spatial cycle hypothesis as shown by a diagram in Figure N-1(a). For a discussion of the type-β and type-γ spatial cycle schemes, see Kawashima (1986).

11) Tokyo Ku-area composed of twenty-three special wards, is defined as Tokyo city. The distance from Tokyo city to the CBD of Tokyo city is the average of "the distance from each special ward to the Prefecture-house of Tokyo."

12) Centralization in the context of this sentence means the situation where population grows faster in inner distance-zones of a metropolitan area as compared with its outer distance-zones, provided that the inner distance-zones are roughly defined as those distance-zones inside the critical circular-line which divides the constituent localities of the metropolitan area into two parts, each part containing approximately the same amount of localities. As its logical consequence, suburbanization means the phenomenon that population generally grows faster in outer distance-zones than inner distance-zones.

13) Table A-2-4, showing annual growth ratio for each locality, would be useful for the purpose of calculating ROXY index for Tokyo FUC shown in Table 3.

14) The stage of decelerating centralization corresponds to the phenomenon that population generally grows faster in the inner distance-zones of a metropolitan area than in its outer distance-zones, but that the discrepancy in population growth rates between inner and outer distance-zones is narrowing. The decelerating centralization could also correspond to the phenomenon that the population growth rates are dominantly positive for localities in inner distance-zones and dominantly negative for localities in outer distance-zones; the difference, however, in the rates between the distance-zone groups is narrowing. It should be noted that the decelerating centralization could additionally mean that population declines slower in inner distance-zones than in outer distance-zones, but that the discrepancy in population decline rates in narrowing.

15) Osaka city is composed of twenty-six wards. The distance from Osaka city to the CBD of Osaka city is the average of "the distance from each ward to the Prefecture Office of Osaka."

16) Table A-3-4, showing annual growth ratio for each locality, would be useful for the calculation of ROXY index for Osaka FUC shown in Table 6.

17) Nagoya city is composed of sixteen wards. The distance from Nagoya city to the CBD of Nagoya city is the average of "the distance from each ward to the Prefecture Office of Nagoya."

18) Taking into consideration the number of localities included in each distance-zone, it seems that the spatial redistribution process of population in Nagoya FUC did not yet arrived at the turning point from the centralization stage to the suburbanization stage by the end of the 1970s.

19) Table A-4-4, showing annual growth ratio for each locality, would be useful for the calculation of ROXY index for Nagoya FUC shown in Table 9.

20) The Kansai Line region in the context of this paper means the region composed of those localities which are situated within Nagoya FUC and in the east side of the Kiso river.

21) Among other possible criteria to be added to these four criteria, would be the criterion on the population growth rate of each spatial unit for the 1975-80 period.

22) Note that, in Tokyo FUC, there are two other primary railway-line regions; the Tokaido Line region extending southwards and the Sobu Line region extending eastwards. They were excluded from our analysis, partly because each of them is bi-centric in the density of economic and residential activities and partly because the number of localities comprising each region is relatively small. If we had included them in our analysis, then we might not have got such a clear "clockwise suburbanization tendency" for Tokyo FUC as we got in our analysis. In this sense, the terminology of "clockwise suburbanization" should be carefully interpreted in order to avoid the misunderstanding of its implications.

23) If we had set a dominance principle, instead of the one we actually applied in Section 3-2, that the fourth criteria on the value of ROXY index for the 1975-80 period is dominant over the third criteria on the time when the speed of suburbanization is maximized, then the rank of "suburbanization advancement" would have been reversed between the Sanyo Line region and the Tokaido Line region. This would suggest to us that the four criteria tentatively set in Section 3-2 for the determination of the rank of "suburbanization advancement" for each spatial unit should be further elaborated to be more consistently persuasive.

24) This figure is drawn based on Table N-2 which can be constructed from Tables 4, 7, 10 and 11.

25) If we add to this figure a dimension of the growth ratio, then more sophisticated and more interesting clulstering criteria could perhaps be introduced.

26) We did not investigate in this study the reasons why such statistical regularities are actually observed as argued by the spatial cycle hypothesis. However, the results of this study would hopefully help to further investigate the causes of such statistical regularities.

Table N-2 The Value of ROXY Index and Its Marginal Change

Spatial Unit	1960-65	1960-65 → 1965-70		1965-70 → 1970-75		1970-75 → 1975-80	
	ROXY	△ROXY	ROXY	△ROXY	ROXY	△ROXY	ROXY
Tokyo FUC	-120.12	51.57	-68.55	48.76	-19.79	23.11	3.32
Osaka FUC	-115.99	37.46	-78.53	60.99	-17.54	30.11	12.57
Nagoya FUC	-77.76	5.71	-72.05	43.26	-28.79	23.57	-5.22
Chuo Line Region	38.73	14.99	53.72	-1.86	51.86	-14.2	37.66
Takasaki Line Region	-73.18	81.14	7.96	37.90	45.86	-6.92	38.94
Joban Line Region	-82.28	56.81	-25.47	41.52	16.05	20.00	36.05
Sanyo Line Region	32.04	23.95	55.99	-5.73	50.26	-10.82	39.44
Tokaido Line Region	45.33	63.36	108.69	-0.18	108.51	-82.39	26.12
Hanwa Line Region	-12.44	19.17	6.73	40.45	47.18	-1.66	45.52
Kansai Line (Up to Kiso River) Region	1.58	22.15	23.73	25.24	48.97	-25.75	23.22
Tokaido Line (North-bound) Region	-21.96	13.68	-8.28	32.52	24.24	10.69	34.93
Tokaido Line (South-bound) Region	2.39	40.71	43.10	-8.14	34.96	-14.44	20.52

(Note)

1. ROXY: Value of ROXY Index for the Second Period
2. △ROXY: Marginal Change in the Value of ROXY Index between the First and Second Periods

27) Among the research items for the development of the analytical method of ROXY index would be;

(i) to investigate the robustness or sensitivity of the ROXY index by examining, for instance, whether the time when the suburbanization starts or the time when the speed of suburbanization is maximized would significantly differ or not depending on the use of ROXY index calculated from the annual growth ratio or the use of ROXY index calculated from the five-year growth ratio,

(ii) to check whether some relationships exist between the value of ROXY index and the number of localities comprising the spatial unit that the ROXY index is calculated for, and

(iii) to increase the number of meaningfully applicable alternative variables to be used as weighting factor (such as density and decision power) in addition to population and distance which have been applied in the calculation of the ROXY index in the previous and present studies respectively by the author.

28) Apart from this study, the author is presently applying the method of ROXY index analysis to the Japanese data in order to test which hypothesis explains the reality better, the "job-follows-people" hypothesis or the "people-follows-job" hypothesis.

APPENDIX 1 SUMMARY OF ROXY INDEX ANALYSES FOR FIVE URBAN SYSTEMS

Table A-1-1 furnishes the values of ROXY index for the period between 1960 and 1980

Table A-1-1 ROXY Index for Five Urban Systems

Country	Group of Spatial Units \ Period	1960–65	1965–70	1970–75	1975–80
Japan	86 FUCs	121.0	84.5	39.5	0.5
	30 FUCs	89.2	42.8	–6.1	–19.3
	24 CCs	–56.1	–119.5	–114.6	–71.3
U.S.	30 SMSAs	–68.5		–59.0	–53.5
	29 CCs	–75.5		–37.0	–19.9

(Note)

1. FUC stands for Functional Urban Core.
2. CC Stands for Central Cities.
3. SMSA stands for Standard Metropolitan Statistical Area.
4. The values of ROXY index for the twenty-nine central cities in the U.S. were calculated using the population data for which the city boundaries are not fixed but variable over time.
5. Six out of the central cities of the thirty largest FUCs have significantly changed their administrative boundaries after 1970, causing us to calculate the ROXY index for the urban system of twenty-four, instead of thirty, central cities in Japan.
6. No population data were available for one of the central cities of the thirty largest SMSAs, so that we calculated the ROXY index for the urban system of twenty-nine, instead of thirty, central cities in the U.S.

concerning the following three kinds of Japanese urban systems and two kinds of U.S. urban systems;

(1) an urban system which is composed of eighty-six FUCs,

(2) an urban system which is composed of the thirty largest FUCs,

(3) an urban system which is composed of central cities of the twenty-four FUCs among the thirty largest FUCs,

(4) an urban system which is composed of the thirty largest SMSAs in the U.S., and

(5) an urban system which is composed of central cities of the twenty-nine SMSAs among the thirty largest SMSAs in the U.S.

The following can be pointed out from this table.

(1) For the urban system of eighty-six FUCs, the ROXY index remained positive throughout the entire 1960-80 period. This implies that the larger FUCs generally grew faster than those with a smaller population. The ROXY index, however, decreased continuously from 121.0 for the 1960-65 period to nearly zero (0.5) for 1975-80, implying that the discrepancy in population growth rates between larger and smaller FUCs was constantly narrowing during the two decades. In other words, the Japanese urban system composed of eighty-six FUCs showed a decelerating concentration of population throughout the entire 1960-1980 period.

(2) For the urban system of the thirty largest FUCs, the ROXY index fell continuously from 89.2 for the 1960-65 period to -19.3 for 1975-80 with the positive sign turning negative around 1970. This implies that before 1970 the population growth rates of larger FUCs generally exceeded those of non-larger FUCs, but also that the discrepancy in rates between the two size groups of FUCs was narrowing. For a while around 1970, population growth in the thirty FUCs became more balanced. After 1970, however, the rates of non-larger FUCs generally exceeded those of larger FUCs and, at the same time, the discrepancy in rates between the size groups was widening with non-larger FUCs showing higher growth rate than the larger FUCs. Put another way, the spatial redistribution of population in the urban system of the thirty FUCs had been deceleratingly concentrating until around 1970. After 1970, the concentration of population ceased and the deconcentration of population started. This tendency of deconcentration continuously accelerated throughout the 1970s.

(3) For the urban system of twenty-four large central cities in Japan, the ROXY index fell from -56.1 for the 1960-65 period to -119.5 for 1965-70. It then began to increase to the value of -114.6 for the 1970-75 period and -71.3 for 1975-80. This implies that, among the twenty-four central cities, the population growth rates of larger central cities were generally exceeded by those of not so large central cities in the first half of the 1960s, and that the speed of population deconcentration in the urban system composed of those twenty-four central cities had been accelerating until the end of the decade. After that, however, the population deconcentra-

tion began to decelerate and this tendency of decelerating deconcentration continued throughout the 1970s.

(4) For the urban system of the thirty largest SMSAs in the U.S., the ROXY index remained negative throughout the entire twenty-year period of 1960-80, but its absolute value gradually decreased from -68.5 for the 1960-70 period to -59.0 for 1970-75 and then to -53.5 for 1975-80. This implies that the population growth rates (or decline rates) of larger SMSAs have always been in general lower (higher) than those of non-larger SMSAs among the largest thirty SMSAs, but that the discrepancy in population growth rates (or decline rates) between larger and non-larger SMSAs was narrowing over time. In other words, the population in the urban system of the thirty SMSAs was deceleratingly deconcentrating in a continuous manner since 1960.

(5) For the urban system of twenty-nine larger central cities in the U.S., the ROXY index remained negative throughout the entire twenty-year period of 1960-80, but its absolute value continuously decreased from -75.5 for the 1960-70 period to -37.0 for 1970-75 and then to -19.9 for 1975-80. This implies, if we can in one way or another assume that the effects of the changes in the boundaries of some of these central cities upon the value of ROXY index would be rather insignificant, that the population deconcentration in the U.S. urban system of the twenty-nine central cities had been continuously decelerating since 1960. However, it should be noticed that this U.S. urban system was at a more advanced stage during 1975-80 than the urban system of the thirty largest SMSAs in light of the theory of spatial cycles (viz. the theory on urban area's or urban system's life cycle phenomena characterized by four metamorphic stages of urbanization, suburbanization, disurbanization and reurbanization) developed by

Table A-1-2 Stage of Spatial Cycles for Five Urban Systems during the 1975-80 Period

Country	Urban System	Spatial Redistribution of Population: Pattern of Dynamic Change for the Second Half of the 1970s	Value of ROXY Index (Type II)	Rank of Urban Advancement
Japan	86 FUCs	Decelerating Concentration (but Close to Stable Share)	0.5	5
	30 FUCs	Accelerating Deconcentration	-19.3	4
	24 CCs	Decelerating Deconcentration	-71.3	3
U.S.	30 SMSAs	Decelerating Deconcentration	-53.5	2
	29 CCs	Decelerating Deconcentration	-19.9	1

(Note) 1. FUC stands for Functional Urban Core.
2. SMSA Stands for Statistical Standard Metropolitan Area.
3. CC stands for Central City.

Klaassen et al. (1981).

Meanwhile, from Table A-1-1, we can construct Table A-1-2 which enables us to compare the stages of spatial cycles for the five kinds of urban systems. This table tells us that the most advanced urban system in terms of the stage of spatial cycles is the one composed of twenty-nine large central cities in the U.S., followed by the urban system of the largest thirty SMSAs, that of twenty-four large central cities in Japan, that of the largest thirty FUCs and that of eighty-six FUCs in this order.

Comprehensively taking into account the above observations on the changes in the value of ROXY index, it would be quite probable that the ROXY index for the urban system composed of the eighty-six FUCs will turn negative during either 1980-85 or 1985-90. This suggests that, in the 1980s, the relatively smaller metropolitan areas will generally begin to grow faster, than the larger metropolitan areas for the first time in the postwar period in Japan. In this sense, the decade of the 1980s could perhaps be viewed as an epochmaking era in the postwar history of Japanese urban systems.

APPENDIX 2 DATA FOR TOKYO FUC

Table A-2-1 Names and Code Numbers of 121 Localities in Tokyo FUC

Code	Name	Code	Name
8203	TSUCHIURA-SHI	11216	HANYU-SHI
8204	KOGA-SHI	11217	KONOSU-SHI
8208	RYUGASAKI-SHI	11218	FUKAYA-SHI
8217	TORIDE-SHI	11219	AGEO-SHI
8444	USHIKU-MACHI	11220	YONO-SHI
8563	FUJISHIRO-MACHI	11221	SOKA-SHI
9364	NOGI-MACHI	11222	KOSHIGAYA-SHI
9366	FUJIOKA-MACHI	11223	WARABI-SHI
11201	KAWAGOE-SHI	11224	TODA-SHI
11202	KUMAGAYA-SHI	11225	IRUMA-SHI
11203	KAWAGUCHI-SHI	11226	HATOGAYA-SHI
11204	URAWA-SHI	11227	ASAKA-SHI
11205	OMIYA-SHI	11230	NIIZA-MACHI
11208	TOKOROZAWA-SHI	11231	OKEGAWA-MACHI
11209	HANNO-SHI	11232	KUKI-MACHI
11210	KASU-SHI	11233	KITAMOTO-MACHI
11212	HIGASHIMATSUYAMA-SHI	11234	YASHIO-MACHI
11213	IWATSUKI-SHI	11235	FUJIMI-MACHI
11214	KASUKABE-SHI	11237	MISATO-MACHI
11215	SAYAMA-SHI	11238	HASUDA-MACHI

(Note) Shi, machi and mura mean city, town and village respectively. "Tokyo Ku-area" means Tokyo city.

Table A-2-1 (Continued)

Code	Name
11239	SAKADO-MACHI
11304	FUKIAGE-MACHI
11305	ADACHI-MACHI
11307	YAMATO-MACHI
11321	FUKUOKA-MACHI
11322	OI-MACHI
11324	MIYOSHI-MURA
11326	MOROYAMA-MACHI
11328	TSURUGASHIMA-MACHI
11329	HIDAKA-MACHI
11346	KAWAJIMA-MURA
11347	YOSHIMI-MURA
11401	OSATO-MURA
11402	KONAN-MURA
11403	MENUMA-MACHI
11406	KAWAMOTO-MURA
11407	HANAZONO-MURA
11408	YORII-MACHI
11425	OTONE-MURA
11442	MIYASHIRO-MACHI
11445	SHIRAOKA-MACHI
11446	SHOBU-MACHI
11461	KURIHASHI-MACHI
11462	WASHIMIYA-MACHI
11463	SATTE-MACHI
11464	SUGITO-MACHI
11465	MATSUBUSHI-MACHI
11466	YOSHIKAWA-MACHI
11468	SHOWA-MACHI
12203	ICHIKAWA-SHI
12204	FUNABASHI-SHI
12207	MATSUDO-SHI
12208	NODA-SHI
12212	SAKURA-SHI
12216	NARASHINO-SHI
12217	KASHIWA-SHI
12220	NAGAREYAMA-SHI
12221	YACHIYO-SHI
12222	ABIKO-SHI
12224	KAMAGAYA-MACHI
12301	URAYASU-MACHI
12305	SHONAN-MACHI
12322	SHISUI-MACHI
12325	INBA-MURA
12326	SHIRAI-MACHI
12327	INZAI-MACHI
12328	MOTONO-MURA
12329	SAKAE-MACHI
13100	TOKYO KU-AREA
13201	HACHIOJI-SHI
13202	TACHIKAWA-SHI
13203	MUSASHINO-SHI
13204	MITAKA-SHI
13206	FUCHU-SHI
13207	AKISHIMA-SHI
13208	CHOFU-SHI
13209	MACHIDA-SHI
13210	KOGANEI-SHI
13211	KODAIRA-SHI
13212	HINO-SHI
13213	HIGASHIMURAYAMA-SHI
13214	KOKUBUNJI-SHI
13215	KUNITACHI-SHI
13216	TANASHI-SHI
13217	HOYA-SHI
13218	FUSSA-SHI
13219	KOMAE-SHI
13220	HIGASHIYAMATO-SHI
13221	KIYOSE-SHI
13222	HIGASHIKURUME-SHI
13224	TAMA-MACHI
13225	INAGI-MACHI
13302	HAMURA-MACHI
13304	AKITA-MACHI
13342	MURAYAMA-MACHI
14130	KAWASAKI-SHI
14209	SAGAMIHARA-SHI
14211	HADANO-SHI
14212	ATSUGI-SHI
14214	ISEHARA-MACHI
14216	ZAMA-MACHI

(Note) Shi, machi and mura mean city, town and village respectively. "Tokyo Ku-area" means Tokyo city.

Table A-2-2 Distance and Population for 121 Localities of Tokyu FUC
(unit: distance = km, population = person)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
13100	7.4	8310027	8893094	8840942	8642800	8349209
12301	12.9	16847	18463	21880	32250	64673
11203	14.8	173692	249112	305886	345547	379357
12203	16.8	157301	207988	261055	319272	364244
11221	17.0	38533	80707	123269	167176	186618
11226	17.2	20711	37403	51377	56693	55952
11224	17.2	30752	52312	69511	77138	78343
14130	17.2	632975	854866	973486	1015022	1040698
13219	17.4	25252	39978	60297	70019	70824
11234	17.5	13307	21772	37323	56127	62734
12207	17.8	86372	160001	253591	344552	400870
11307	18.0	17242	31034	39512	46504	49718
11223	18.0	50952	69715	77225	76312	70876
13204	18.5	98038	135873	155693	164852	164449
13203	18.5	120337	133516	136959	139493	136895
11237	19.5	17738	24207	42753	79354	98222
13217	19.7	46768	71303	86194	91537	91251
12204	20.0	135038	223989	325426	423106	479437
11227	20.2	24182	51527	67938	81755	90088
13208	20.3	68621	117995	157488	175858	180535
13216	21.2	31323	49113	58466	67432	66972
11230	22.0	14401	30001	77704	108990	119312
11204	23.2	174437	221323	269397	331145	358180
13222	23.5	19637	47239	78075	100821	106521
12220	23.5	25672	39166	56485	82936	106635
13225	23.7	11012	19345	30817	43921	48154
13210	23.7	45734	76350	94448	102703	102412
11222	23.8	49585	76571	139368	195915	223243
12216	24.0	42167	64477	99951	117851	125154
11305	24.2	12259	20464	31811	43546	50926
12224	24.3	13496	25002	40988	63291	76157
11466	24.5	16300	16761	18524	30786	38895
13221	24.5	17863	36448	51911	60571	61915
13206	25.8	82098	126235	163173	182379	191980
11220	26.0	40840	51746	62802	71045	72326
13211	26.2	52923	105365	137373	156182	154610
13214	27.5	39098	64911	81259	88155	91014
11235	27.6	12030	23767	52011	70392	79591
11324	27.8	4329	5911	14475	23596	28978
11465	27.8	8844	9308	12207	15806	18463
13213	28.0	42946	74857	96545	112657	119382

Table A-2-2 (Continued)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
11205	28.0	169996	215646	268777	327696	354082
12217	28.6	63745	109239	150635	203063	239199
12305	28.7	11849	15262	18480	22148	33706
13224	29.0	9746	18376	30370	65465	95248
13215	29.2	32609	43477	59709	64404	64154
11208	30.0	65903	89346	136611	196868	236477
12326	30.2	8217	8305	10509	12968	24975
11322	30.7	4949	9876	19613	31989	35538
11213	30.7	35169	41946	56449	83825	94695
12221	30.8	21709	35741	66630	113263	134479
12208	30.8	54150	59799	68641	78194	93958
13202	31.0	81951	100699	117057	138097	142600
11321	31.2	16652	34050	51747	58332	57929
13220	31.3	14239	31709	46173	58465	65415
12222	31.7	27063	33216	49240	76218	101061
13209	32.2	71269	115918	202801	255303	295354
11214	32.7	34280	42460	84919	121639	155556
13212	33.2	43394	67979	98557	126754	145417
13342	35.0	12065	14049	41275	50842	57194
11468	35.0	15808	16780	18909	25217	32356
11238	35.6	20743	25070	31935	39043	45594
13207	36.3	44805	59655	75662	83856	89343
8217	36.5	22582	26179	40287	52821	71246
11219	36.5	38889	54776	110792	146359	166244
11201	37.0	107523	127155	171038	225467	259317
14209	37.2	101655	163381	278326	377341	439257
11215	37.5	32785	40183	60886	98548	124025
11225	37.7	36903	51835	65369	83996	104034
11442	38.2	11152	13025	16656	22526	29538
11464	38.5	16457	17634	20244	28074	34549
11445	38.6	16026	17937	21990	27691	31623
12327	38.6	17315	16863	16114	16832	17896
14216	39.7	15402	29948	56727	80565	93501
13218	40.0	21985	30790	37938	46456	48710
11231	40.2	21309	28108	38717	48034	55746
13201	40.3	164622	207753	253527	322558	387162
8563	41.4	12606	13002	16309	20407	26464
13302	42.0	11003	16027	22783	33124	42018
12212	42.0	36869	40941	60433	80807	101180
11346	42.2	16443	15594	15049	15999	17393
12328	42.3	5213	5052	4566	4585	4622
13304	42.7	14433	17271	28357	38272	42805

Table A-2-2 (Continued)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
12325	43.0	7912	7639	7331	7444	7452
11232	43.2	23114	26773	34028	45799	54410
11233	44.0	15483	20576	31699	46632	50888
11209	44.0	44153	47825	52066	55925	61178
11463	44.2	23378	25169	27923	43083	49704
11328	44.3	7008	9583	14634	20994	35843
14212	44.7	46239	61383	82888	108952	145387
11239	44.8	23569	24854	27308	51230	77334
11446	45.0	16054	15500	15238	16166	19462
11329	45.0	16683	17768	21646	32338	43221
8208	45.6	33581	34917	37267	40569	43131
12322	46.0	6093	6040	6259	8463	12807
12329	46.5	9732	9333	8825	8952	9553
11462	47.2	8351	8436	9099	20576	21257
8444	48.0	16131	17203	19372	27674	40170
11217	48.0	31868	36526	41990	51632	57085
11347	48.8	14915	14229	14072	14724	16108
11326	49.8	11173	14885	20006	25807	31197
11461	49.8	12890	14489	16112	18090	19792
14214	50.8	26984	32013	43751	61621	70052
11210	51.2	41756	41547	42149	45184	47590
11212	51.6	38267	42706	50383	57682	63889
11425	51.8	11821	11655	12037	12739	13536
11304	54.5	12095	14482	17247	18775	22606
11401	57.2	7222	6896	6782	6790	7000
8204	58.0	42474	50202	54173	55971	56656
8203	58.5	71378	78971	89958	104031	112517
11216	59.0	42900	43884	45001	46506	48488
14211	59.3	51285	57930	75226	103677	123130
11202	61.7	98168	109575	120841	131486	136807
11402	62.0	7801	7709	8485	9164	10181
9364	62.5	9974	10339	11983	14015	16453
9366	65.0	20299	19624	19397	19952	20377
11406	67.0	9452	9282	9764	10984	11567
11407	70.0	7775	7759	7958	8718	9873
11408	70.5	25478	25298	25137	25846	28466
11403	72.5	21317	20759	20847	22275	24624
11218	72.5	51024	53067	60609	75750	82243
Total	4377.2	13388959	15844973	18005893	19955814	21049507

Table A-2-3 Five-year Growth Rate of Population for 121 Localities of Tokyo FUC (%)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
13100	7.4	7.02	−0.59	−2.24	−3.40
12301	12.9	9.59	18.51	47.39	100.54
11203	14.8	43.42	22.79	12.97	9.78
12203	16.8	32.22	25.51	22.30	14.09
11221	17.0	109.45	52.74	35.62	11.63
11226	17.2	80.59	37.36	10.35	−1.31
11224	17.2	70.11	32.88	10.97	1.56
14130	17.2	35.06	13.88	4.27	2.53
13219	17.4	58.32	50.83	16.12	1.15
11234	17.5	63.61	71.43	50.38	11.77
12207	17.8	85.25	58.49	35.87	16.35
11307	18.0	79.99	27.32	17.70	6.91
11223	18.0	36.82	10.77	−1.18	−7.12
13204	18.5	38.59	14.59	5.88	−0.24
13203	18.5	10.95	2.58	1.85	−1.86
11237	19.5	36.47	76.61	85.61	23.78
13217	19.7	52.46	20.88	6.20	−0.31
12204	20.0	65.87	45.29	30.02	13.31
11227	20.2	113.08	31.85	20.34	10.19
13208	20.3	71.95	33.47	11.66	2.66
13216	21.2	56.80	19.04	15.34	−0.68
11230	22.0	156.10	110.69	40.26	9.47
11204	23.2	26.88	21.72	22.92	8.16
13222	23.5	140.56	65.28	29.13	5.65
12220	23.5	52.56	44.22	46.83	28.58
13225	23.7	75.67	59.30	42.52	9.64
13210	23.7	66.94	23.70	8.74	−0.28
11222	23.8	54.42	82.01	40.57	13.95
12216	24.0	52.91	55.02	17.91	6.20
11305	24.2	66.93	55.45	36.89	16.95
12224	24.3	85.25	63.94	54.41	20.33
11466	24.5	2.83	10.52	66.20	26.34
13221	24.5	104.04	42.42	16.68	2.22
13206	25.8	53.76	29.26	11.77	5.26
11220	26.0	26.70	21.37	13.13	1.80
13211	26.2	99.09	30.38	13.69	−1.01
13214	27.5	66.02	25.19	8.49	3.24
11235	27.6	97.56	118.84	35.34	13.07
11324	27.8	36.54	144.88	63.01	22.81
11465	27.8	5.25	31.15	29.48	16.81
13213	28.0	74.30	28.97	16.69	5.97
11205	28.0	26.85	24.64	21.92	8.05

Table A-2-3 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
12217	28.6	71.37	37.89	34.80	17.80
12305	28.7	28.80	21.09	19.85	52.19
13224	29.0	88.55	65.27	115.56	45.49
13215	29.2	33.33	37.33	7.86	-0.39
11208	30.0	35.57	52.90	44.11	20.12
12326	30.2	1.07	26.54	23.40	92.59
11322	30.7	99.56	98.59	63.10	11.09
11213	30.7	19.27	34.58	48.50	12.97
12221	30.8	64.64	86.42	69.99	18.73
12208	30.8	10.43	14.79	13.92	20.16
13202	31.0	22.88	16.24	17.97	3.26
11321	31.2	104.48	51.97	12.73	-0.69
13220	31.3	122.69	45.61	26.62	11.89
12222	31.7	22.74	48.24	54.79	32.59
13209	32.2	62.65	74.95	25.89	15.69
11214	32.7	23.86	100.00	43.24	27.88
13212	33.2	56.66	44.98	28.61	14.72
13342	35.0	16.44	193.79	23.18	12.49
11468	35.0	6.15	12.69	33.36	28.31
11238	35.6	20.86	27.38	22.26	16.78
13207	36.3	33.14	26.83	10.83	6.54
8217	36.5	15.93	53.89	31.11	34.88
11219	36.5	40.85	102.26	32.10	13.59
11201	37.0	18.26	34.51	31.82	15.01
14209	37.2	60.72	70.35	35.58	16.41
11215	37.5	22.57	51.52	61.86	25.85
11225	37.7	40.46	26.11	28.50	23.86
11442	38.2	16.80	27.88	35.24	31.13
11464	38.5	7.15	14.80	38.68	23.06
11445	38.6	11.92	22.60	25.93	14.20
12327	38.6	-2.61	-4.44	4.46	6.32
14216	39.7	94.44	89.42	42.02	16.06
13218	40.0	40.05	23.22	22.45	4.85
11231	40.2	31.91	37.74	24.06	16.06
13201	40.3	26.20	22.03	27.23	20.03
8563	41.4	3.14	25.43	25.13	29.68
13302	42.0	45.66	42.15	45.39	26.85
12212	42.0	11.04	47.61	33.71	25.21
11346	42.2	-5.16	-3.49	6.31	8.71
12328	42.3	-3.09	-9.62	0.42	0.81
13304	42.7	19.66	64.19	34.96	11.84
12325	43.0	-3.45	-4.03	1.54	0.11

Table A-2-3 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
11232	43.2	15.83	27.10	34.59	18.80
11233	44.0	32.89	54.06	47.11	9.13
11209	44.0	8.32	8.87	7.41	9.39
11463	44.2	7.66	10.94	54.29	15.37
11328	44.3	36.74	52.71	43.46	70.73
14212	44.7	32.75	35.03	31.44	33.44
11239	44.8	5.45	9.87	87.60	50.95
11446	45.0	-3.45	-1.69	6.09	20.39
11329	45.0	6.50	21.83	49.39	33.65
8208	45.6	3.98	6.73	8.86	6.32
12322	46.0	-0.87	3.63	35.21	51.33
12329	46.5	-4.10	-5.44	1.44	6.71
11462	47.2	1.02	7.86	126.13	3.31
8444	48.0	6.65	12.61	42.86	45.15
11217	48.0	14.62	14.96	22.96	10.56
11347	48.8	-4.60	-1.10	4.63	9.40
11326	49.8	33.22	34.40	29.00	20.89
11461	49.8	12.40	11.20	12.28	9.41
14214	50.8	18.64	36.67	40.84	13.68
11210	51.2	-0.50	1.45	7.20	5.32
11212	51.6	11.60	17.98	14.49	10.76
11425	51.8	-1.40	3.28	5.83	6.26
11304	54.5	19.74	19.09	8.86	20.40
11401	57.2	-4.51	-1.65	0.12	3.09
8204	58.0	18.19	7.91	3.32	1.22
8203	58.5	10.64	13.91	15.64	8.16
11216	59.0	2.29	2.55	3.34	4.26
14211	59.3	12.96	29.86	37.82	18.76
11202	61.7	11.62	10.28	8.81	4.05
11402	62.0	-1.18	10.07	8.00	11.10
9364	62.5	3.66	15.90	16.96	17.40
9366	65.0	-3.33	-1.16	2.86	2.13
11406	67.0	-1.80	5.19	12.49	5.31
11407	70.0	-0.21	2.56	9.55	13.25
11408	70.5	-0.71	-0.64	2.82	10.14
11403	72.5	-2.62	0.42	6.85	10.55
11218	72.5	4.00	14.21	24.98	8.57

Table A-2-4 Annual Growth Ratio of Population for 121 Localities of Tokyo FUC

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
13100	7.4	1.0137	0.9988	0.9955	0.9931
12301	12.9	1.0185	1.0345	1.0807	1.1493
11203	14.8	1.0748	1.0419	1.0247	1.0188
12203	16.8	1.0575	1.0465	1.0411	1.0267
11221	17.0	1.1594	1.0884	1.0628	1.0222
11226	17.2	1.1255	1.0655	1.0199	0.9974
11224	17.2	1.1121	1.0585	1.0210	1.0031
14130	17.2	1.0619	1.0263	1.0084	1.0050
13219	17.4	1.0962	1.0857	1.0303	1.0023
11234	17.5	1.1035	1.1138	1.0850	1.0225
12207	17.8	1.1312	1.0965	1.0632	1.0307
11307	18.0	1.1247	1.0495	1.0331	1.0135
11223	18.0	1.0647	1.0207	0.9976	0.9853
13204	18.5	1.0675	1.0276	1.0115	0.9995
13203	18.5	1.0210	1.0051	1.0037	0.9962
11237	19.5	1.0642	1.1205	1.1317	1.0436
13217	19.7	1.0880	1.0387	1.0121	0.9994
12204	20.0	1.1065	1.0776	1.0539	1.0253
11227	20.2	1.1633	1.0569	1.0377	1.0196
13208	20.3	1.1145	1.0594	1.0223	1.0053
13216	21.2	1.0941	1.0355	1.0289	0.9986
11230	22.0	1.2069	1.1607	1.0700	1.0183
11204	23.2	1.0488	1.0401	1.0421	1.0158
13222	23.5	1.1919	1.1057	1.0525	1.0111
12220	23.5	1.0882	1.0760	1.0798	1.0516
13225	23.7	1.1193	1.0976	1.0734	1.0186
13210	23.7	1.1079	1.0435	1.0169	0.9994
11222	23.8	1.0908	1.1272	1.0705	1.0265
12216	24.0	1.0886	1.0916	1.0335	1.0121
11305	24.2	1.1079	1.0922	1.0648	1.0318
12224	24.3	1.1312	1.1039	1.0908	1.0377
11466	24.5	1.0056	1.0202	1.1069	1.0479
13221	24.5	1.1533	1.0733	1.0313	1.0044
13206	25.8	1.0899	1.0527	1.0225	1.0103
11220	26.0	1.0485	1.0395	1.0250	1.0036
13211	26.2	1.1477	1.0545	1.0260	0.9980
13214	27.5	1.1067	1.0459	1.0164	1.0064
11235	27.6	1.1459	1.1696	1.0624	1.0249
11324	27.8	1.0643	1.1962	1.1027	1.0419
11465	27.8	1.0103	1.0557	1.0530	1.0316
13213	28.0	1.1175	1.0522	1.0313	1.0117
11205	28.0	1.0487	1.0450	1.0404	1.0156

Table A-2-4 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
12217	28.6	1.1137	1.0664	1.0616	1.0333
12305	28.7	1.0519	1.0390	1.0369	1.0876
13224	29.0	1.1352	1.1057	1.1660	1.0779
13215	29.2	1.0592	1.0655	1.0153	0.9992
11208	30.0	1.0628	1.0886	1.0758	1.0373
12326	30.2	1.0021	1.0482	1.0429	1.1401
11322	30.7	1.1482	1.1471	1.1028	1.0213
11213	30.7	1.0359	1.0612	1.0823	1.0247
12221	30.8	1.1049	1.1327	1.1119	1.0349
12208	30.8	1.0200	1.0280	1.0264	1.0374
13202	31.0	1.0421	1.0306	1.0336	1.0064
11321	31.2	1.1538	1.0873	1.0242	0.9986
13220	31.3	1.1737	1.0781	1.0483	1.0227
12222	31.7	1.0418	1.0819	1.0913	1.0580
13209	32.2	1.1022	1.1184	1.0471	1.0296
11214	32.7	1.0437	1.1487	1.0745	1.0504
13212	33.2	1.0939	1.0771	1.0516	1.0279
13342	35.0	1.0309	1.2405	1.0426	1.0238
11468	35.0	1.0120	1.0242	1.0593	1.0511
11238	35.6	1.0386	1.0496	1.0410	1.0315
13207	36.3	1.0589	1.0487	1.0208	1.0128
8217	36.5	1.0300	1.0900	1.0557	1.0617
11219	36.5	1.0709	1.1513	1.0573	1.0258
11201	37.0	1.0341	1.0611	1.0568	1.0284
14209	37.2	1.0995	1.1124	1.0628	1.0309
11215	37.5	1.0415	1.0867	1.1011	1.0471
11225	37.7	1.0703	1.0475	1.0514	1.0437
11442	38.2	1.0315	1.0504	1.0622	1.0557
11464	38.5	1.0139	1.0280	1.0676	1.0424
11445	38.6	1.0228	1.0416	1.0472	1.0269
12327	38.6	0.9947	0.9910	1.0088	1.0123
14216	39.7	1.1422	1.1363	1.0727	1.0302
13218	40.0	1.0697	1.0426	1.0413	1.0095
11231	40.2	1.0569	1.0661	1.0441	1.0302
13201	40.3	1.0476	1.0406	1.0493	1.0372
8563	41.4	1.0062	1.0464	1.0459	1.0534
13302	42.0	1.0781	1.0729	1.0777	1.0487
12212	42.0	1.0212	1.0810	1.0598	1.0460
11346	42.2	0.9895	0.9929	1.0123	1.0168
12328	42.3	0.9937	0.9800	1.0008	1.0016
13304	42.7	1.0366	1.1043	1.0618	1.0226
12325	43.0	0.9930	0.9918	1.0031	1.0002

Table A-2-4 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
11232	43.2	1.0298	1.0491	1.0612	1.0351
11233	44.0	1.0585	1.0903	1.0803	1.0176
11209	44.0	1.0161	1.0171	1.0144	1.0181
11463	44.2	1.0149	1.0210	1.0906	1.0290
11328	44.3	1.0646	1.0884	1.0748	1.1129
14212	44.7	1.0583	1.0619	1.0562	1.0594
11239	44.8	1.0107	1.0190	1.1341	1.0858
11446	45.0	0.9930	0.9966	1.0119	1.0378
11329	45.0	1.0127	1.0403	1.0836	1.0597
8208	45.6	1.0078	1.0131	1.0171	1.0123
12322	46.0	0.9983	1.0071	1.0622	1.0864
12329	46.5	0.9917	0.9889	1.0029	1.0131
11462	47.2	1.0020	1.0152	1.1773	1.0065
8444	48.0	1.0130	1.0240	1.0739	1.0774
11217	48.0	1.0277	1.0283	1.0422	1.0203
11347	48.8	0.9906	0.9978	1.0091	1.0181
11326	49.8	1.0590	1.0609	1.0522	1.0387
11461	49.8	1.0237	1.0215	1.0234	1.0181
14214	50.8	1.0348	1.0645	1.0709	1.0260
11210	51.2	0.9990	1.0029	1.0140	1.0104
11212	51.6	1.0222	1.0336	1.0274	1.0207
11425	51.8	0.9972	1.0065	1.0114	1.0122
11304	54.5	1.0367	1.0356	1.0171	1.0378
11401	57.2	0.9908	0.9967	1.0002	1.0061
8204	58.0	1.0340	1.0153	1.0066	1.0024
8203	58.5	1.0204	1.0264	1.0295	1.0158
11216	59.0	1.0045	1.0050	1.0066	1.0084
14211	59.3	1.0247	1.0536	1.0663	1.0350
11202	61.7	1.0222	1.0198	1.0170	1.0080
11402	62.0	0.9976	1.0194	1.0155	1.0213
9364	62.5	1.0072	1.0300	1.0318	1.0326
9366	65.0	0.9933	0.9977	1.0057	1.0042
11406	67.0	0.9964	1.0102	1.0238	1.0104
11407	70.0	0.9996	1.0051	1.0184	1.0252
11408	70.5	0.9986	0.9987	1.0056	1.0195
11403	72.5	0.9947	1.0008	1.0133	1.0203
11218	72.5	1.0079	1.0269	1.0456	1.0166

Table A-2-5 *Five-year Growth Rate of Population for Localities of Three Railway-line Regions in Tokyo FUC (%)*

(a) Chuo Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
13100	7.4	7.02	−0.59	−2.24	−3.40
13204	18.5	38.59	14.59	5.88	−0.24
13203	18.5	10.95	2.58	1.85	−1.86
13210	23.7	66.94	23.70	8.74	−0.28
13206	25.8	53.76	29.26	11.77	5.26
13214	27.5	66.02	25.19	8.49	3.24
13215	29.2	33.33	37.33	7.86	−0.39
13202	31.0	22.88	16.24	17.97	3.26
13212	33.2	56.66	44.98	28.61	14.72
13201	40.3	26.20	22.03	27.23	20.03

(b) Takasaki Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
13100	7.4	7.02	−0.59	−2.24	−3.40
11203	14.8	43.42	22.79	12.97	9.78
11226	17.2	80.59	37.36	10.35	−1.31
11223	18.0	36.82	10.77	−1.18	−7.12
11204	23.2	26.88	21.72	22.92	8.16
11220	26.0	26.70	21.37	13.13	1.80
11205	28.0	26.85	24.64	21.92	8.05
11219	36.5	40.85	102.26	32.10	13.59
11231	40.2	31.91	37.74	24.06	16.06
11233	44.0	32.89	54.06	47.11	9.13
11217	48.0	14.62	14.96	22.96	10.56
11304	54.5	19.74	19.09	8.86	20.40
11202	61.7	11.62	10.28	8.81	4.05
11218	72.5	4.00	14.21	24.98	8.57

(c) Joban Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
13100	7.4	7.02	−0.59	−2.24	−3.40
12207	17.8	85.25	58.49	35.87	16.35
12217	28.6	71.37	37.89	34.80	17.80
12222	31.7	22.74	48.24	54.79	32.59
8217	36.5	15.93	53.89	31.11	34.88
8563	41.4	3.14	25.43	25.13	29.68
8208	45.6	3.98	6.73	8.86	6.32
8444	48.0	6.65	12.61	42.86	45.15
8203	58.5	10.64	13.91	15.64	8.16

APPENDIX 3 DATA FOR OSAKA FUC

Table A-3-1 Names and Code Numbers of 68 Localities in Osaka FUC

Code	Name	Code	Name
24208	NABARI-SHI	27361	KUMATORI-MACHI
27100	OSAKA-SHI	27362	TAJIRI-MACHI
27201	SAKAI-SHI	27366	MISAKI-MACHI
27202	KISHIWADA-SHI	27367	HANNAN-MACHI
27203	TOYONAKA-SHI	27381	TAISHI-MACHI
27204	IKEDA-SHI	27382	KANAN-MACHI
27205	SUITA-SHI	27384	SAYAMA-MACHI
27206	IZUMIOTSU-SHI	27385	MIHARA-MACHI
27207	TAKATSUKI-SHI	28202	AMAGASAKI-SHI
27208	KAIZUKA-SHI	28204	NISHINOMIYA-SHI
27209	MORIGUCHI-SHI	28206	ASHIYA-SHI
27210	HIRAKATA-SHI	28207	ITAMI-SHI
27211	IBARAKI-SHI	28214	TAKARAZUKA-SHI
27212	YAO-SHI	28217	KAWANISHI-SHI
27213	IZUMISANO-SHI	29202	YAMATOTAKADA-SHI
27214	TONDABAYASHI-SHI	29203	YAMATOKORIYAMA-SHI
27215	NEYAGAWA-SHI	29205	KASHIWARA-SHI
27216	KAWACHINAGANO-SHI	29206	SAKURAI-SHI
27217	MATSUBARA-SHI	29208	GOSE-SHI
27218	DAITO-SHI	29209	IKOMA-MACHI
27219	IZUMI-SHI	29342	HEGURI-MURA
27220	MINOO-SHI	29343	SANGO-MACHI
27221	KASHIWARA-SHI	29344	IKARUGA-MACHI
27222	HABIKINO-SHI	29363	TAWARAMOTO-MACHI
27223	KADOMA-SHI	29383	HAIBARA-MACHI
27224	SETTSU-SHI	29401	TAKATORI-MACHI
27225	TAKAISHI-SHI	29421	SHINJO-MACHI
27226	FUJIIDERA-SHI	29422	TAIMA-MACHI
27227	HIGASHIOSAKA-SHI	29423	KASHIBA-MACHI
27228	SENNAN-SHI	29425	OJI-MACHI
27229	SHIJONAWATE-SHI	29426	KORYO-MACHI
27230	KATANO-MACHI	29427	KAWAI-MURA
27301	SHIMAMOTO-MACHI	29442	OYODO-MACHI
27341	TADAOKA-MACHI	30203	HASHIMOTO-SHI

(Note) Shi, machi and mura mean city, town and village respectively.

Table A-3-2 Distance and Population for 68 Localities of Osaka FUC
(unit: distance = km, population = person)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
27100	4.7	3011563	3156222	2980487	2778975	2648158
27209	7.1	102295	138856	184466	178379	165635
27205	8.2	116795	196665	259619	300949	332413
27227	8.6	318001	443081	500173	524731	521635
27223	8.8	34228	95209	141041	143235	138901
27212	9.7	123035	170248	227778	261642	272706
27218	10.1	35354	57107	93136	110829	116625
27224	10.9	24360	43479	59758	76704	80686
28202	11.5	405955	500472	553696	545762	523657
27203	11.6	199065	292050	368498	398363	403185
27217	12.1	46834	71406	111562	132662	135852
27229	12.6	10779	19317	37893	52371	50582
27201	12.6	371502	466412	594367	750671	810120
27215	13.5	50188	113576	206961	254316	255864
27226	14.0	26509	38221	50414	59516	63727
27211	15.2	71859	115136	163903	210286	234059
27221	15.5	35645	44972	53104	63585	69836
28207	15.5	86455	121380	153763	171979	178229
27222	16.1	36982	50333	77134	94160	103147
29209	16.4	23138	28511	35550	48844	70456
27220	16.4	34249	43851	57414	79620	104113
27385	16.5	12057	17429	22191	26319	29314
27204	17.2	59688	82478	94333	100263	101116
28204	17.3	262608	337391	377043	400590	410329
29342	17.9	6141	6408	7899	11706	16854
27230	18.6	11825	17533	33701	52735	61425
29343	18.7	6723	8061	10023	13772	17949
28217	18.7	41916	61282	87127	115771	129834
27210	18.8	80312	127520	217369	297618	353360
28214	19.2	66491	91486	127179	162622	183628
27225	19.5	34104	45679	61442	66824	66810
29425	19.8	9507	11849	14783	16333	17212
28206	20.0	57050	63195	70938	76211	81741
27207	20.0	79043	130735	231129	330571	340722
27384	20.2	9648	12502	19198	36045	46508
29344	21.2	10657	13115	16892	20739	25751
27214	21.6	36261	47985	75754	91393	97423
27381	21.7	5970	5818	6374	7384	8741
27206	22.2	42304	53312	59437	66243	67474
29424	22.4	4134	4270	4483	11499	16448

Table A-3-2 (Continued)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
29427	22.9	6546	6717	7693	12076	15789
29423	23.0	15009	17481	21205	26582	36314
27382	23.7	8839	9204	8941	12261	13967
27219	23.8	70701	84771	95987	118234	124322
27341	24.5	12218	15077	16795	17754	18053
29203	24.5	43093	45765	57456	71000	81262
29422	25.7	7379	8044	8516	10209	12915
27216	25.8	34399	40109	51994	66945	78573
27301	25.9	9173	12939	16873	22404	24663
29426	26.3	15598	16936	17355	17984	18425
29202	27.3	41705	47371	53475	58638	61713
27202	28.0	120265	143710	162022	174947	180317
29421	28.7	10049	10871	12915	15477	16626
29363	28.9	19769	20150	20988	25555	28172
27208	31.0	61067	69365	73366	79506	81162
29205	31.6	49954	57065	75508	95697	107320
29208	31.7	35549	35788	35987	37555	37388
29206	35.0	47752	49773	52081	54315	56441
27361	35.1	10815	12211	13808	18032	25431
27213	35.4	56827	66521	77000	86139	90684
29401	36.3	9819	9572	9413	9193	8909
27362	38.5	8204	7887	8382	7785	7519
29442	41.6	15114	15626	15930	16059	16510
30203	41.7	32015	32807	33334	35320	35922
27228	41.9	32075	35235	38206	46741	53325
27367	44.2	21067	23919	28322	37382	42612
29383	48.9	12934	12873	12950	12846	17209
27366	52.9	19133	20083	20684	22423	22864
Total	1527.4	6828298	8272422	9495198	10351276	10666632

Table A-3-3 Five-year Growth Rate of Population for 68 Localities of Osaka FUC (%)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27100	4.7	4.80	−5.57	−6.76	−4.71
27209	7.1	35.74	32.85	−3.30	−7.14
27205	8.2	68.38	32.01	15.92	10.45
27227	8.6	39.33	12.89	4.91	−0.59
27223	8.8	178.16	48.14	1.56	−3.03
27212	9.7	38.37	33.79	14.87	4.23
27218	10.1	61.53	63.09	19.00	5.23
27224	10.9	78.49	37.44	28.36	5.19
28202	11.5	23.28	10.63	−1.43	−4.05
27203	11.6	46.71	26.18	8.10	1.21
27217	12.1	52.47	56.24	18.91	2.40
27229	12.6	79.21	96.16	38.21	−3.42
27201	12.6	25.55	27.43	26.30	7.92
27215	13.5	126.30	82.22	22.88	0.61
27226	14.0	44.18	31.90	18.05	7.08
27211	15.2	60.22	42.36	28.30	11.31
27221	15.5	26.17	18.08	19.74	9.83
28207	15.5	40.40	26.68	11.85	3.63
27222	16.1	36.10	53.25	22.07	9.54
29209	16.4	23.22	24.69	37.40	44.25
27220	16.4	28.04	30.93	38.68	30.76
27385	16.5	44.56	27.32	18.60	11.38
27204	17.2	38.18	14.37	6.29	0.85
28204	17.3	28.48	11.75	6.25	2.43
29342	17.9	4.35	23.27	48.20	43.98
27230	18.6	48.27	92.21	56.48	16.48
29343	18.7	19.90	24.34	37.40	30.33
28217	18.7	46.20	42.17	32.88	12.15
27210	18.8	58.78	70.46	36.92	18.73
28214	19.2	37.59	39.01	27.87	12.92
27225	19.5	33.94	34.51	8.76	−0.02
29425	19.8	24.63	24.76	10.49	5.38
28206	20.0	10.77	12.25	7.43	7.26
27207	20.0	65.40	76.79	43.02	3.07
27384	20.2	29.58	53.56	87.75	29.03
29344	21.2	23.06	28.80	22.77	24.17
27214	21.6	32.33	57.87	20.64	6.60
27381	21.7	−2.55	9.56	15.85	18.38
27206	22.2	26.02	11.49	11.45	1.86
29424	22.4	3.29	4.99	156.50	43.04
29427	22.9	2.61	14.53	56.97	30.75
29423	23.0	16.47	21.30	25.36	36.61

Table A-3-3 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27382	23.7	4.13	-2.86	37.13	13.91
27219	23.8	19.90	13.23	23.18	5.15
27341	24.5	23.40	11.39	5.71	1.68
29203	24.5	6.20	25.55	23.57	14.45
29422	25.7	9.01	5.87	19.88	26.51
27216	25.8	16.60	29.63	28.76	17.37
27301	25.9	41.06	30.40	32.78	10.08
29426	26.3	8.58	2.47	3.62	2.45
29202	27.3	13.59	12.89	9.65	5.24
27202	28.0	19.49	12.74	7.98	3.07
29421	28.7	8.18	18.80	19.84	7.42
29363	28.9	1.93	4.16	21.76	10.24
27208	31.0	13.59	5.77	8.37	2.08
29205	31.6	14.24	32.32	26.74	12.15
29208	31.7	0.67	0.56	4.36	-0.44
29206	35.0	4.23	4.64	4.29	3.91
27361	35.1	12.91	13.08	30.59	41.03
27213	35.4	17.06	15.75	11.87	5.28
29401	36.3	-2.52	-1.66	-2.34	-3.09
27362	38.5	-3.86	6.28	-7.12	-3.42
29442	41.6	3.39	1.95	0.81	2.81
30203	41.7	2.47	1.61	5.96	1.70
27228	41.9	9.85	8.43	22.34	14.09
27367	44.2	13.54	18.41	31.99	13.99
29383	48.9	-0.47	0.60	-0.80	33.96
27366	52.9	4.97	2.99	8.41	1.97

Table A-3-4 Annual Growth Ratio of Population for 68 Localities of Osaka FUC

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27100	4.7	1.0094	0.9886	0.9861	0.9904
27209	7.1	1.0630	1.0584	0.9933	0.9853
27205	8.2	1.1098	1.0571	1.0300	1.0201
27227	8.6	1.0686	1.0245	1.0096	0.9988
27223	8.8	1.2270	1.0818	1.0031	0.9939
27212	9.7	1.0671	1.0600	1.0281	1.0083
27218	10.1	1.1007	1.1028	1.0354	1.0102
27224	10.9	1.1228	1.0657	1.0512	1.0102
28202	11.5	1.0428	1.0204	0.9971	0.9918
27203	11.6	1.0797	1.0476	1.0157	1.0024
27217	12.1	1.0880	1.0933	1.0353	1.0048
27229	12.6	1.1238	1.1443	1.0669	0.9931
27201	12.6	1.0466	1.0497	1.0478	1.0154
27215	13.5	1.1774	1.1275	1.0421	1.0012
27226	14.0	1.0759	1.0569	1.0338	1.0138
27211	15.2	1.0989	1.0732	1.0511	1.0217
27221	15.5	1.0476	1.0338	1.0367	1.0189
28207	15.5	1.0702	1.0484	1.0226	1.0072
27222	16.1	1.0636	1.0891	1.0407	1.0184
29209	16.4	1.0426	1.0451	1.0656	1.0760
27220	16.4	1.0507	1.0554	1.0676	1.0551
27385	16.5	1.0765	1.0495	1.0347	1.0218
27204	17.2	1.0668	1.0272	1.0123	1.0017
28204	17.3	1.0514	1.0225	1.0122	1.0048
29342	17.9	1.0085	1.0427	1.0819	1.0756
27230	18.6	1.0820	1.1396	1.0937	1.0310
29343	18.7	1.0370	1.0445	1.0656	1.0544
28217	18.7	1.0789	1.0729	1.0585	1.0232
27210	18.8	1.0969	1.1126	1.0649	1.0349
28214	19.2	1.0659	1.0681	1.0504	1.0246
27225	19.5	1.0602	1.0611	1.0169	1.0000
29425	19.8	1.0450	1.0452	1.0201	1.0105
28206	20.0	1.0207	1.0234	1.0144	1.0141
27207	20.0	1.1059	1.1207	1.0742	1.0061
27384	20.2	1.0532	1.0896	1.1343	1.0523
29344	21.2	1.0424	1.0519	1.0419	1.0442
27214	21.6	1.0576	1.0956	1.0382	1.0129
27381	21.7	0.9949	1.0184	1.0299	1.0343
27206	22.2	1.0473	1.0220	1.0219	1.0037
29424	22.4	1.0065	1.0098	1.2073	1.0742
29427	22.9	1.0052	1.0275	1.0944	1.0551
29423	23.0	1.0310	1.0394	1.0462	1.0644

Table A-3-4 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27382	23.7	1.0081	0.9942	1.0652	1.0264
27219	23.8	1.0370	1.0252	1.0426	1.0101
27341	24.5	1.0429	1.0218	1.0112	1.0033
29203	24.5	1.0121	1.0466	1.0432	1.0274
29422	25.7	1.0174	1.0115	1.0369	1.0481
27216	25.8	1.0312	1.0533	1.0518	1.0325
27301	25.9	1.0712	1.0545	1.0583	1.0194
29426	26.3	1.0166	1.0049	1.0071	1.0049
29202	27.3	1.0258	1.0245	1.0186	1.0103
27202	28.0	1.0363	1.0243	1.0155	1.0061
29421	28.7	1.0158	1.0351	1.0369	1.0144
29363	28.9	1.0038	1.0082	1.0402	1.0197
27208	31.0	1.0258	1.0113	1.0162	1.0041
29205	31.6	1.0270	1.0576	1.0485	1.0232
29208	31.7	1.0013	1.0011	1.0086	0.9991
29206	35.0	1.0083	1.0091	1.0084	1.0077
27361	35.1	1.0246	1.0249	1.0548	1.0712
27213	35.4	1.0320	1.0297	1.0227	1.0103
29401	36.3	0.9949	0.9967	0.9953	0.9937
27362	38.5	0.9921	1.0122	0.9853	0.9931
29442	41.6	1.0067	1.0039	1.0016	1.0056
30203	41.7	1.0049	1.0032	1.0116	1.0034
27228	41.9	1.0190	1.0163	1.0411	1.0267
27367	44.2	1.0257	1.0344	1.0571	1.0265
29383	48.9	0.9991	1.0012	0.9984	1.0602
27366	52.9	1.0097	1.0059	1.0163	1.0039

Table A-3-5 Five-year Growth Rate of Population for Localities of Three Railway-line Regions in Osaka FUC (%)

(a) Sanyo Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27100	4.7	4.80	-5.57	-6.76	-4.71
28202	11.5	23.28	10.63	-1.43	-4.05
28204	17.3	28.48	11.75	6.25	2.43
28206	20.0	10.77	12.25	7.43	7.26

(b) Tokaido Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27100	4.7	4.80	-5.57	-6.76	-4.71
27205	8.2	68.38	32.01	15.92	10.45
27224	10.9	78.49	37.44	28.36	5.19
27211	15.2	60.22	42.36	28.30	11.31
27207	20.0	65.40	76.79	43.02	3.07
27301	25.9	41.06	30.40	32.78	10.08

(c) Hanwa Line Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
27100	4.7	4.80	-5.57	-6.76	-4.71
27201	12.6	25.55	27.43	26.30	7.92
27225	19.5	33.94	34.51	8.76	-0.02
27206	22.2	26.02	11.49	11.45	1.86
27219	23.8	19.90	13.23	23.18	5.15
27341	24.5	23.40	11.39	5.71	1.68
27202	28.0	19.49	12.74	7.98	3.07
27208	31.0	13.59	5.77	8.37	2.08
27361	35.1	12.91	13.08	30.59	41.03
27213	35.4	17.06	15.75	11.87	5.28
27228	41.9	9.85	8.43	22.34	14.09
27367	44.2	13.54	18.41	31.99	13.99

APPENDIX 4 DATA FOR NAGOYA FUC

Table A-4-1 Names and Code Numbers of 64 Localities in Nagoya FUC

Code	Name	Code	Name
21204	TAJIMI-SHI	23345	HARUHI-MURA
21323	NANNO-MACHI	23346	KIYOSU-MACHI
21522	KANI-MACHI	23347	SHINKAWA-MACHI
23100	NAGOYA-SHI	23361	OGUCHI-MACHI
23203	ICHINOMIYA-SHI	23362	FUSO-MACHI
23204	SETO-SHI	23381	KISOGAWA-MACHI
23205	HANDA-SHI	23401	SOBUE-MACHI
23206	KASUGAI-SHI	23402	HEIWA-MACHI
23208	TSUSHIMA-SHI	23421	SHIPPO-MACHI
23210	KARIYA-SHI	23422	MIWA-MACHI
23212	ANJO-SHI	23423	JIMOKUJI-MACHI
23215	INUYAMA-SHI	23424	OHARU-MURA
23216	TOKONAME-SHI	23425	KANIE-MACHI
23217	KONAN-SHI	23426	JUSHIYAMA-MURA
23218	BISAI-SHI	23428	YATOMI-MACHI
23219	KOMAKI-SHI	23429	SAYA-MACHI
23220	INAZAWA-SHI	23432	SAORI-MACHI
23222	TOKAI-SHI	23441	AGUI-MACHI
23223	OBU-SHI	23442	HIGASHIURA-MACHI
23224	CHITA-SHI	23446	MIHAMA-MACHI
23225	CHIRYU-SHI	23447	TAKETOYO-MACHI
23226	OWARIASAHI-SHI	24202	YOKKAICHI-SHI
23227	TAKAHAMA-SHI	24205	KUWANA-SHI
23228	IWAKURA-SHI	24207	SUZUKA-SHI
23229	TOYOAKE-SHI	24210	KAMEYAMA-SHI
23302	TOGO-MACHI	24301	TADO-MACHI
23303	NISSHIN-SHI	24302	NAGASHIMA-MACHI
23304	NAGAKUTE-MURA	24323	DAIAN-MACHI
23341	NISHIBIWAJIMA-MACHI	24341	KOMONO-MACHI
23342	TOYOYAMA-MURA	24342	KUSU-MACHI
23343	SHIKATSU-MACHI	24344	KAWAGOE-MACHI
23344	NISHIHARU-MACHI	24381	KAWAGE-MACHI

(Note) Shi, machi and mura mean city, town and village respectively.

Table A-4-2 Distance and Population for 64 Localities of Nagoya FUC
(unit: distance = km, population = person)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
23341	3.8	16981	19119	19637	19630	18532
23347	5.4	16241	18987	20127	19815	18896
23100	5.8	1697093	1935430	2036053	2079694	2087884
23346	7.3	10153	12913	14878	16051	17076
23343	7.7	8082	11806	24658	34177	38844
23423	7.7	11422	15240	20626	25703	28268
23342	7.8	4612	6908	11005	13867	13692
23424	8.0	6455	10689	13907	17685	19939
23344	8.1	8765	13205	22082	28987	30234
23345	8.7	3169	4318	5110	5668	6632
23206	9.7	77174	117384	161835	213856	244114
23421	10.0	6433	7938	14161	19186	21134
23422	11.2	7374	10050	14067	18787	20786
23228	11.5	14431	21459	33843	41935	42800
23425	11.5	15639	20147	24377	28770	30965
23219	12.4	43470	60877	79606	97441	103234
23304	13.1	6639	7583	11317	14500	18612
23303	13.3	11187	13573	21486	32736	41024
23220	13.7	51735	64480	78180	88616	90892
23426	15.0	4656	4776	5070	5613	5656
23208	15.0	43198	46559	51441	58243	59049
23222	15.2	33965	57069	86608	95455	96049
23432	15.3	14027	15211	18365	20712	21525
23402	16.0	8915	9854	12438	13489	13598
23302	16.2	6200	6697	11509	15598	22128
23429	16.2	12026	13981	17556	24385	27025
23361	16.8	10163	12248	14898	15894	16195
23203	16.8	182984	203743	219274	238457	253138
23229	17.0	15366	22945	29776	45828	54673
23204	17.0	82101	86424	92681	112564	120775
23217	17.3	49278	61773	77996	90418	92141
23428	18.2	15784	19210	22241	27098	30801
23401	18.7	19197	19871	20011	20474	21535
23223	19.0	26137	34740	48960	56211	62277
23362	19.8	11344	14984	21317	25293	27254
23218	20.0	51218	52220	51337	54243	55088
23224	20.5	32602	34739	39834	56564	64832
24302	21.0	8555	8843	9774	11256	12632
23381	21.6	23861	25903	25530	26168	27239
23215	22.3	38202	43007	50594	58746	64614

Table A-4-2 (Continued)

Code Number	Distance	Population				
		1960	1965	1970	1975	1980
23210	22.8	59245	70018	87671	96154	105643
23442	23.0	20425	22194	24550	33081	36035
23225	23.7	20542	26800	41896	47212	49432
24205	24.0	69391	75712	81015	83437	86606
24301	25.0	10610	10726	10614	10886	11072
21204	26.7	53793	60175	63522	68901	74311
23441	27.3	12918	13775	18499	20863	20878
24344	27.8	8388	9931	10605	11078	10644
21323	28.3	12484	12556	12389	15003	16706
23227	28.7	20853	25321	31102	32193	31548
23212	29.0	66793	76152	94307	111042	123842
21522	30.5	26063	26114	28235	36649	55248
23205	32.0	71380	76027	80663	85826	89328
23216	33.0	51919	52815	54168	54867	54346
24202	35.0	195974	218981	229234	247000	255442
23447	36.2	17103	21059	25575	30255	33924
24323	37.2	11250	11048	11052	11503	11835
24342	38.7	10405	11805	12171	11887	11314
24341	40.5	20217	21332	24187	27543	29373
23226	42.1	18577	24473	33634	44061	53149
24207	44.0	96822	106588	121185	141829	156249
23446	44.6	19327	19006	19227	20408	20820
24210	54.4	30950	30582	30623	32325	33486
24381	55.2	10341	10966	14287	17127	17012
Total	1361.3	3642604	4201059	4714576	5180943	5430025

Table A-4-3 Five-year Growth Rate of Population for 64 Localities of Nagoya FUC (%)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23341	3.8	12.59	2.71	-0.04	-5.59
23347	5.4	16.91	6.00	-1.55	-4.64
23100	5.8	14.04	5.20	2.14	0.39
23346	7.3	27.18	15.22	7.88	6.39
23343	7.7	46.08	108.86	38.60	13.66
23423	7.7	33.43	35.34	24.61	9.98
23342	7.8	49.78	59.31	26.01	-1.26
23424	8.0	65.59	30.11	27.17	12.75
23344	8.1	50.66	67.22	31.27	4.30
23345	8.7	36.26	18.34	10.92	17.01
23206	9.7	52.10	37.87	32.14	14.15
23421	10.0	23.39	78.40	35.48	10.15
23422	11.2	36.29	39.97	33.55	10.64
23228	11.5	48.70	57.71	23.91	2.06
23425	11.5	28.83	21.00	18.02	7.63
23219	12.4	40.04	30.77	22.40	5.95
23304	13.1	14.22	49.24	28.13	28.36
23303	13.3	21.33	58.30	52.36	25.32
23220	13.7	24.64	21.25	13.35	2.57
23426	15.0	2.58	6.16	10.71	0.77
23208	15.0	7.78	10.49	13.22	1.38
23222	15.2	68.02	51.76	10.21	0.62
23432	15.3	8.44	20.73	12.78	3.93
23402	16.0	10.53	26.22	8.45	0.81
23302	16.2	8.02	71.85	35.53	41.86
23429	16.2	16.26	25.57	38.90	10.83
23361	16.8	20.52	21.64	6.69	1.89
23203	16.8	11.34	7.62	8.75	6.16
23229	17.0	49.32	29.77	53.91	19.30
23204	17.0	5.27	7.24	21.45	7.29
23217	17.3	25.36	26.26	15.93	1.91
23428	18.2	21.71	15.78	21.84	13.67
23401	18.7	3.51	0.70	2.31	5.18
23223	19.0	32.92	40.93	14.81	10.79
23362	19.8	32.09	42.27	18.65	7.75
23218	20.0	1.96	-1.69	5.66	1.56
23224	20.5	6.55	14.67	42.00	14.62
24302	21.0	3.37	10.53	15.16	12.22
23381	21.6	8.56	-1.44	2.50	4.09
23215	22.3	12.58	17.64	16.11	9.99
23210	22.8	18.18	25.21	9.68	9.87
23442	23.0	8.66	10.62	34.75	8.93

Table A-4-3 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23225	23.7	30.46	56.33	12.69	4.70
24205	24.0	9.11	7.00	2.99	3.80
24301	25.0	1.09	−1.04	2.56	1.71
21204	26.7	11.86	5.56	8.47	7.85
23441	27.3	6.63	34.29	12.78	0.07
24344	27.8	18.40	6.79	4.46	−3.92
21323	28.3	0.58	−1.33	21.10	11.35
23227	28.7	21.43	22.83	3.51	−2.00
23212	29.0	14.01	23.84	17.75	11.53
21522	30.5	0.20	8.12	29.80	50.75
23205	32.0	6.51	6.10	6.40	4.08
23216	33.0	1.73	2.56	1.29	−0.95
24202	35.0	11.74	4.68	7.75	3.42
23447	36.2	23.13	21.44	18.30	12.13
24323	37.2	−1.80	0.04	4.08	2.89
24342	38.7	13.46	3.10	−2.33	−4.82
24341	40.5	5.52	13.38	13.88	6.64
23226	42.1	31.74	37.43	31.00	20.63
24207	44.0	10.09	13.69	17.04	10.17
23446	44.6	−1.66	1.16	6.14	2.02
24210	54.4	−1.19	0.13	5.56	3.59
24381	55.2	6.04	30.28	19.88	−0.67

Table A-4-4 Annual Growth Ratio of Population for 64 Localities of Nagoya FUC

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23341	3.8	1.0240	1.0054	0.9999	0.9886
23347	5.4	1.0317	1.0117	0.9969	0.9905
23100	5.8	1.0266	1.0102	1.0043	1.0008
23346	7.3	1.0493	1.0287	1.0153	1.0125
23343	7.7	1.0787	1.1587	1.0675	1.0259
23423	7.7	1.0594	1.0624	1.0450	1.0192
23342	7.8	1.0842	1.0976	1.0473	0.9975
23424	8.0	1.1061	1.0540	1.0492	1.0243
23344	8.1	1.0854	1.1083	1.0559	1.0085
23345	8.7	1.0638	1.0343	1.0209	1.0319
23206	9.7	1.0875	1.0663	1.0573	1.0268
23421	10.0	1.0429	1.1227	1.0626	1.0195
23422	11.2	1.0639	1.0696	1.0596	1.0204
23228	11.5	1.0826	1.0954	1.0438	1.0041
23425	11.5	1.0520	1.0389	1.0337	1.0148
23219	12.4	1.0697	1.0551	1.0413	1.0116
23304	13.1	1.0269	1.0834	1.0508	1.0512
23303	13.3	1.0394	1.0962	1.0879	1.0462
23220	13.7	1.0450	1.0393	1.0254	1.0051
23426	15.0	1.0051	1.0120	1.0206	1.0015
23208	15.0	1.0151	1.0201	1.0251	1.0028
23222	15.2	1.1094	1.0870	1.0196	1.0012
23432	15.3	1.0163	1.0384	1.0243	1.0077
23402	16.0	1.0202	1.0477	1.0164	1.0016
23302	16.2	1.0155	1.1144	1.0627	1.0724
23429	16.2	1.0306	1.0466	1.0679	1.0208
23361	16.8	1.0380	1.0400	1.0130	1.0038
23203	16.8	1.0217	1.0148	1.0169	1.0120
23229	17.0	1.0835	1.0535	1.0901	1.0359
23204	17.0	1.0103	1.0141	1.0396	1.0142
23217	17.3	1.0462	1.0477	1.0300	1.0038
23428	18.2	1.0401	1.0297	1.0403	1.0259
23401	18.7	1.0069	1.0014	1.0046	1.0102
23223	19.0	1.0586	1.0710	1.0280	1.0207
23362	19.8	1.0572	1.0730	1.0348	1.0150
23218	20.0	1.0039	0.9966	1.0111	1.0031
23224	20.5	1.0128	1.0277	1.0726	1.0277
24302	21.0	1.0066	1.0202	1.0286	1.0233
23381	21.6	1.0166	0.9971	1.0049	1.0081
23215	22.3	1.0240	1.0330	1.0303	1.0192
23210	22.8	1.0340	1.0460	1.0186	1.0190
23442	23.0	1.0168	1.0204	1.0615	1.0173

Table A-4-4 (Continued)

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23225	23.7	1.0546	1.0935	1.0242	1.0092
24205	24.0	1.0176	1.0136	1.0059	1.0075
24301	25.0	1.0022	0.9979	1.0051	1.0034
21204	26.7	1.0227	1.0109	1.0164	1.0152
23441	27.3	1.0129	1.0607	1.0243	1.0001
24344	27.8	1.0343	1.0132	1.0088	0.9920
21323	28.3	1.0012	0.9973	1.0390	1.0217
23227	28.7	1.0396	1.0420	1.0069	0.9960
23212	29.0	1.0266	1.0437	1.0332	1.0221
21522	30.5	1.0004	1.0157	1.0535	1.0856
23205	32.0	1.0127	1.0119	1.0125	1.0080
23216	33.0	1.0034	1.0051	1.0026	0.9981
24202	35.0	1.0224	1.0092	1.0150	1.0067
23447	36.2	1.0425	1.0396	1.0342	1.0232
24323	37.2	0.9964	1.0001	1.0080	1.0057
24342	38.7	1.0256	1.0061	0.9953	0.9902
24341	40.5	1.0108	1.0254	1.0263	1.0129
23226	42.1	1.0567	1.0657	1.0555	1.0382
24207	44.0	1.0194	1.0260	1.0320	1.0196
23446	44.6	0.9967	1.0023	1.0120	1.0040
24210	54.4	0.9976	1.0003	1.0109	1.0071
24381	55.2	1.0118	1.0543	1.0369	0.9987

Table A-4-5 Five-year Growth Rate of Population for Localities of Three Railway-line Regions in Nagoya FUC (%)

(a) Kansai Line (Up to Kiso River) Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23100	5.8	14.04	5.20	2.14	0.39
23425	11.5	28.83	21.00	18.02	7.63
23208	15.0	7.78	10.49	13.22	1.38
23429	16.2	16.26	25.57	38.90	10.83
23428	18.2	21.71	15.78	21.84	13.67

(b) Tokaido Line (North-bound) Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23341	3.8	12.59	2.71	-0.04	-5.59
23347	5.4	16.91	6.00	-1.55	-4.64
23100	5.8	14.04	5.20	2.14	0.39
23346	7.3	27.18	15.22	7.88	6.39
23220	13.7	24.64	21.25	13.35	2.57
23203	16.8	11.34	7.62	8.75	6.16
23381	21.6	8.56	-1.44	2.50	4.09

(c) Tokaido Line (South-bound) Region

Code Number	Distance	1960–1965	1965–1970	1970–1975	1975–1980
23100	5.8	14.04	5.20	2.14	0.39
23223	19.0	32.92	40.93	14.81	10.79
23210	22.8	18.18	25.21	9.68	9.87
23442	23.0	8.66	10.62	34.75	8.93
23225	23.7	30.46	56.33	12.69	4.70
23212	29.0	14.01	23.84	17.75	11.53